POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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NRA MEMBER U.S. WE DO OUR PART

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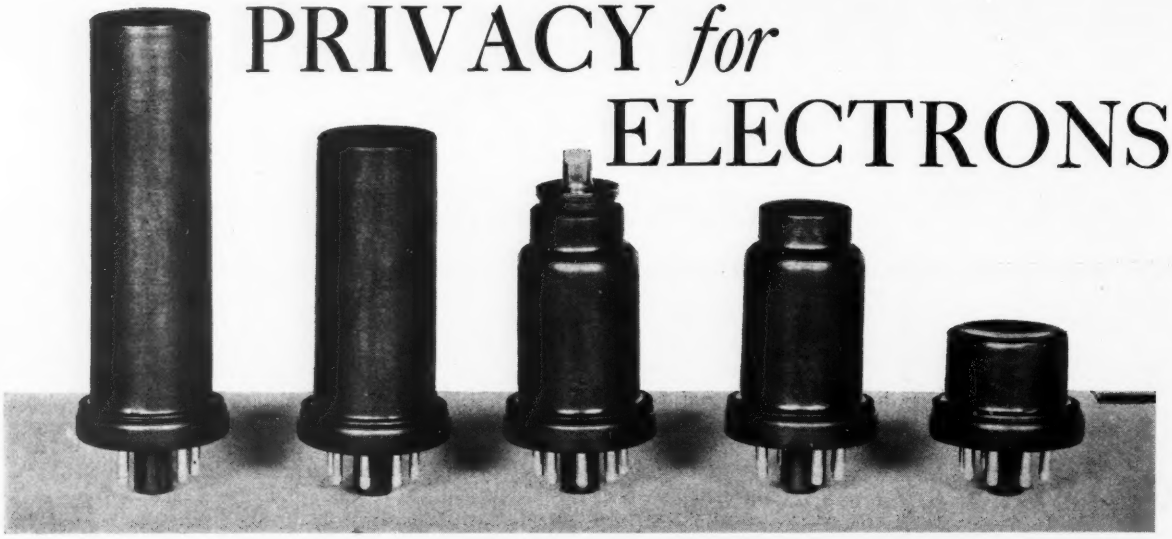
PRIVACY *for* ELECTRONS



NO LONGER WILL the electrons in radio tubes be exposed to the merciless gaze of curious human beings. From now on, they will conduct their operations in the absolute privacy afforded by these new metal enclosed tubes developed in the research laboratories of the General Electric Co.

Whether this development is of any significance to the electrons we have no means of knowing; we think not, but it is of considerable importance to the human beings using the tubes. For these tubes are not only much smaller and more compact than the orthodox glass tubes but they are more efficient and, obviously, much more rugged. Looking at them, now, in their little metal overcoats one wonders why it has not been done before—the advantages seem so obvious. Why were "tubes" not made of metal in the first place?

Well, it is rather a long story and we can not go into it here: much of the delay was due to insufficient mastery over the technical processes involved in their construction but more, probably, was due to the mental inertia that tends to carry most human efforts along the path of least resistance—to what Branch Cabel has called the "rivet in grandfather's neck." The thermionic effect was first observed in a tube made of glass—one of Edison's first incandescent lamps. The lamp consisted of an incandescent filament in an evacuated bulb. When the thermionic tube was developed by Fleming, this also required an incandescent filament in an evacuated bulb so it was only natural that it should take the form of a lamp, since the technique for making lamps had been well developed by that time. Once started in a certain direction it was difficult to alter the course of a development so important and so astonishing as the thermionic tube. Furthermore, glass tubes performed very well; despite their fragile envelope they were remarkably rugged and could withstand almost any duty imposed upon them—until quite recently.

Then, along came Huey Long, General Johnson and the Rev. Coughlin and the trouble began. Under the terrific impact of the invective—the scathing denunciations and imprecations hurled into the microphones by these gentlemen, the poor glass tubes which had at various times successfully transmitted the roar of Niagara Falls could no longer stand up—something far stronger was necessary, armor plated tubes "er somethin'."

So, here we have them—a whole row of them, guaranteed not to bend or buckle under the combined outpourings of Messrs Long, Coughlin and Johnson all in one studio. They can take it.

Aside from this aspect of their use, these tubes are of unusual significance in the general industrial field and the field of heavy power engineering because their development removes once and for all time the objection that tubes are too fragile for use in heavy industrial service. For, despite their increasing application in the industrial field, many "power" engineers still regard "vacuum" tubes with distrust and extreme caution. Granting their usefulness, they have been hesitant in applying them in their own plants.

With the development of all metal tubes these mental hazards are automatically removed and the thermionic tube can take its proper place alongside the solenoid, the contactor, the motor or any of the innumerable electrical devices commonly used in industrial plants. Details of these new tubes are given on page 315.

Enclosing the elements in a metal shell, however, removes a certain amount of romance which the glowing filament in a tube seems to impart to it. To a radio engineer, particularly, nothing is quite so lovely as the soft radiance from these wonderful devices in a partially darkened room, for in their glow he sees their power—the power of hurling the spoken word across the hundreds of millions of square miles of the earth's surface. It is this mental picture, perhaps, which imparts to the communication engineer a significance, a romance, to the glowing vacuum tube that the industrial engineer using tubes can never understand. So the radio engineer will probably regard this latest development in thermionic tube practice with a tinge of sadness.

And, of course, we haven't said anything about the Scotchman who returned his radio set because he could not read his newspaper by the light from the tubes.

WITH THE EDITORS

Air Conditioning

AMONG MODERN MARVELS of engineering, the development of air conditioning equipment ranks high and probably contributes more to human comfort than any other with the exception of heating. Perhaps it would be more correct to say that it offers greater potentialities than any other development because the application has lagged far behind the development work.

Restaurants, hotels and movie theaters deserve their full share of credit for pioneer applications and for doing so much to popularize the practice. Although air conditioning for the home may yet be beyond the means of the majority, the practicability of air conditioning has been fully demonstrated and its gradual adoption will eventually result in volume production with a corresponding decrease in cost of equipment.

The domestic field is, however, but one phase of air conditioning work. There still remains the vast field of industrial air conditioning to be considered. Here we are dealing with something more tangible than human comfort, definite increases in production, less spoilage and reduced labor costs.

Dealing with larger capacities and factory installation, standard refrigeration units, air washers and cooling coils may be used and, with no development costs to consider, it is questionable if an increased volume of business will have any appreciable effect on price. There is, therefore, no reason why such work should be delayed in hopes of lower costs in the future, in fact indications are that equipment costs will increase.

There is nothing mysterious about air conditioning, nothing that warrants the common impression that it is a new and jealously guarded branch of engineering. Naturally as in every other field experience is an invaluable factor in design but the fundamental principles are as old as mechanical refrigeration itself. In heating installations the heat flow through the walls of the heated rooms is calculated from the expected temperature difference, the construction of the wall and wind velocities and this, corrected for equipment and people in the room, opening doors and fresh air supply forms the basis for determining the necessary radiating surface and steam demand.

With cooling, conditions are reversed and heat flows from the outside in. These heat flow calculations are exactly the same as the heating calculations and must be corrected for the same factors but in this case the radiators or heat exchangers must absorb rather than radiate heat. That is, a refrigerating machine takes the place of the boiler. The only additional factor to be considered is the humidity, an integral part of air conditions but generally neglected in heating calculations. In fact heating is but a special branch of air conditioning.

Especially since the development of the steam jet refrigerating unit, air conditioning affords many opportunities to improve the general industrial plant heat balance. Large quantities of industrial water can often be used to absorb this heat at a distinct saving in hot water heating steam, thus giving the necessary refrigeration effect at practically no additional heat consumption.

Breweries, distilleries, printing and paper plants, textile mills, candy and tobacco factories, chemical and many other industries have found air conditioning a distinct advantage. Wherever temperature or humidity has an appreciable effect on the manufactured product, where the labor turnover is high in summer or the spoilage great, industrial engineers should thoroughly investigate the possibilities of correcting those difficulties by air conditioning.

Engineers' License and Personal Development

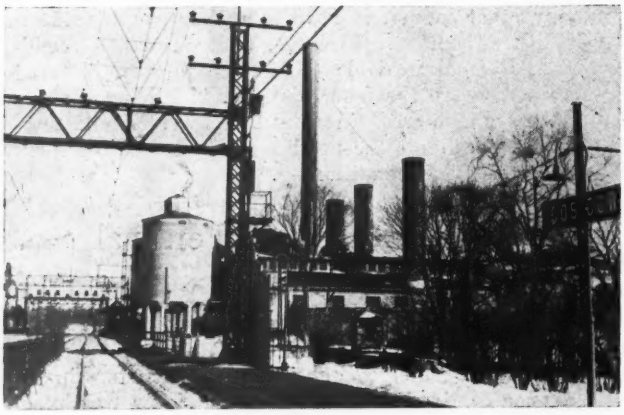
THROUGHOUT the entire history of power plant engineering as a profession, education, training and experience have stood out as dominant factors in the advance of the industry. Every engineer worthy of the name places safety above everything else in importance, with economy second in rank. This statement of general policy seems simple but it is not so easy to put into practice, in fact nearly every engineer who has risen to a responsible position has had his moral courage taxed many times in order to maintain absolute safety.

At the present time the question of engineers' license laws is up for consideration in several states and the confusion of ideas that prevails relative to the workings of a license law needs considerable clarifying. In the enactment of such laws, safety again is of prime importance and probably the only basis upon which license laws will stand in court. Whatever economic benefit may come to the licensed engineer, by way of increased salary, or to the plant owner, by way of added security from accidents or economies effected by higher class engineering, can be considered from a legal viewpoint only as by-products and not as fundamental reasons for enactment of the law.

License laws, as a rule, are designed to keep out of responsible positions the inexperienced, the uninformed, the incompetent, the untrustworthy individuals who are a detriment to the plant and a danger to fellow workmen. The required knowledge and experience usually specified are representative of that required by concerns that have a reputation for discrimination in the selection of their employes for specific purposes, and in the opinion of engineers generally those requirements are reasonable.

It is quite evident that sound license laws have had a beneficial effect on the caliber of engineers in charge of steam plant equipment but whatever may be the outcome of the present license law agitation, personal development can come to the engineer only through educational methods relentlessly pursued and his responsibility for safety is in no way affected by political laws.

Improving Performance at COS COB STATION



ON THE NEW YORK, New Haven and Hartford Railroad, not far out of New York City, just a few miles south of Stamford in fact, is a small station called Cos Cob. To the main line traveler between New York and Boston, it is an unimportant station, indeed, the express trains do not stop there, but to the New York, New Haven and Hartford Railroad it is one of the most important stations on the system. For at this point is located the power station which supplies the major part of the electrical energy used on the system.

Aside from its strategic importance the Cos Cob station is of interest historically because of its gradual growth over a thirty year period of power plant development. Each time as extensions became necessary, advantage was taken of the steady progress in the field of steam and electric generation and each time more modern equipment was selected. Just recently two new steam generators were placed in service but before we describe these units, a brief history of the plant will be of interest.

The plant was built during 1905-6 to serve the then newly electrified New York division of the railroad. Upon completion of the project in 1907 we find the plant operating with three turbo generators and twelve 500 hp. B. & W. boilers operating at a pressure of 200 lb. which were fired with bituminous coal burned on underfeed stokers. This plant proved inadequate for the load and during 1908 and 1909 two more 500 hp. B. & W. boilers were installed along with a fourth turbo generator. This constituted the original Cos Cob Power Plant, the boilers being housed in what is now the East Boiler Room and the turbines in the portion of the present turbine room adjacent to it.

In 1912, after three years of operation, the plant was enlarged to include another boiler room known as the West Boiler Room with 14—620 hp. Bigelow Hornsby boilers, the second installation of its kind in the country, and four turbo generators were installed in an addition to the turbine room. These boilers also operated at a working pressure of 200 lb. and were likewise fired wih bituminous coal on underfeed stokers.

Coaling facilities originally consisted of a tidewater tower and 250 t. bunkers at one end of each boiler room. These small bunkers served weigh larries of 5000 lb. capacity each which traveled down each side of each firing aisle. Later arrangements for unloading rail coal were installed and finally a radial bridge spanning a 10,000 t. circular storage field served the plant through ring crushers, inclined belt and two 1000 t. concrete bunkers located at the end of each boiler room opposite to the small 250 t. bunkers which are now used only in emergency.

About one mile up the Mianus River from the plant a dam has been built impounding a very large reservoir of fresh water for plant uses. At the dam a pumping and filtration plant, consisting of three Diesel driven centrifugal pumps and four slow sand pressure filters with provisions for alum coagulation and chlorine treatment operates to furnish the 1,000,000 gal. per day to the two 600,000 gal. concrete sedimentation tanks at the power plant.

The turbo generators, with the exception of one old, little used unit, are all equipped with jet condensers. Fresh water make-up is, therefore, extremely high and will probably never be reduced to below about 85 per cent unless the main generating units are again changed.

Some ten years ago, realizing that the boilers were approaching the end of their useful life and anticipating condemnation action by the insurance authorities, plans were made for replacing some of the older units with new ones. Accordingly, in 1927 two modern replacement units were installed as the first step in a rehabilitation program.

These new units were radical departures from the generally known design, being the newly developed

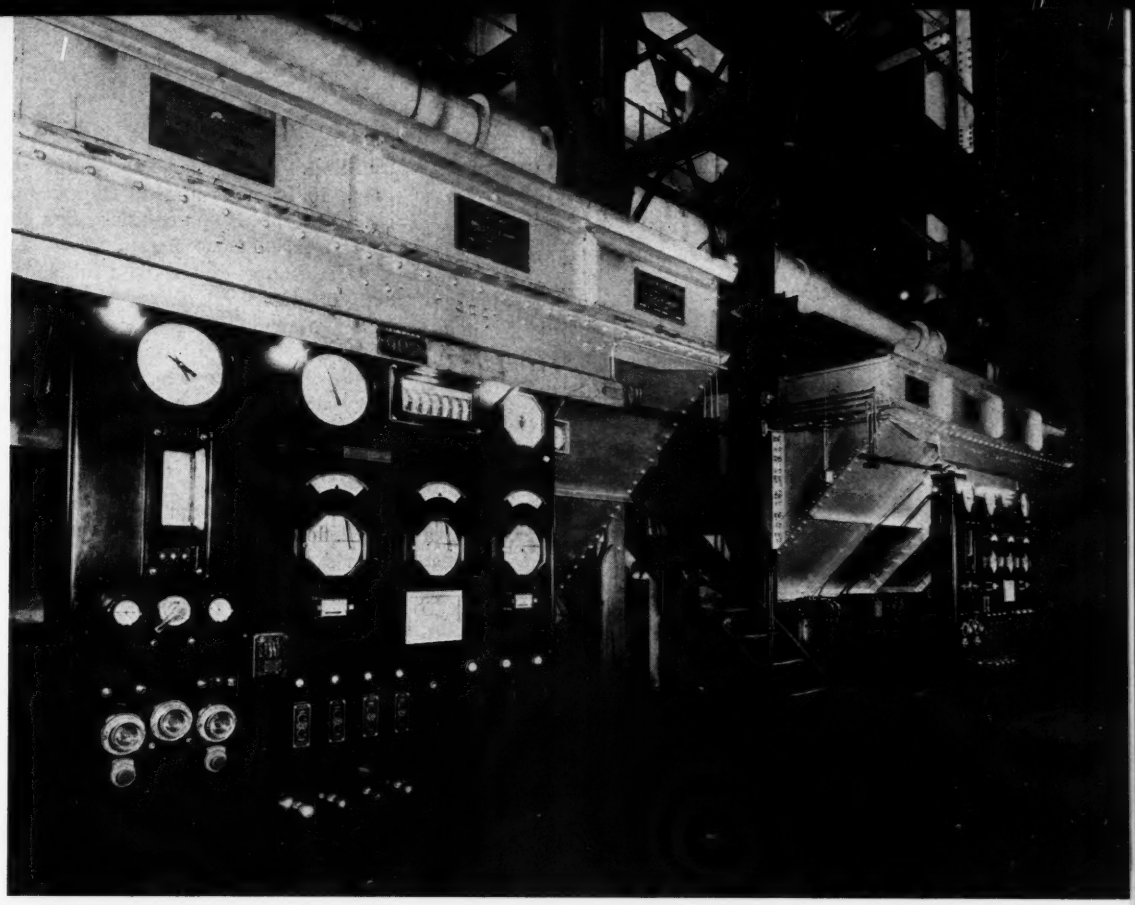


FIG. 1

View of Control Boards at the new Boiler Units at Cos Cob.

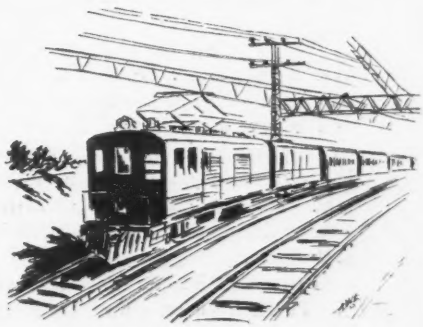
Combustion Steam Generators of the Combustion Engineering Co., fired by pulverized coal. They are capable of producing over 85,000 lb. of steam per hr. at 320 lb. gage pressure, with an operating efficiency of 85 per cent. These units constituted complete boiler plants in themselves with forced and induced draft fans, raw coal feeders and pulverizers, burners and air preheaters. Their operation was rendered completely automatic by the use of the Smoot Automatic control system. Along with these boilers, new feed water pumps and heaters were installed, all with the basic idea of tying in with additional replacement when and if the occasion demanded.

Early in 1933 it was decided to proceed with the second step in the rehabilitation program and in line with the present trend towards fewer and larger units, to install two new pulverized fuel fired boilers, each capable of producing steam at the rate of 150,000 lb. per hr. for a 15 min. peak, 125,000 lb. per hr. continuously for 2 hr., or a sustained output of 110,000 lb. per hr. Owing to the size of these units and the characteristics of the Cos Cob load, it was furthermore specified that each boiler must perform satisfactorily over a fluctuating 5 to 1 operating range or from 30,000 lb. to 150,000 lb. rate of output.

The plant is now being operated at a steam pressure of 200 lb. per sq. in. Three of the old original turbo generator units were replaced in 1923-26 with modern machines, each having almost three times the generating capacity of the old units. These new machines are designed for an ultimate steam operating pressure of a little less than 300 lb. per sq. in. They have, however, been operated at the old plant pressure of 200 lb. on account of necessity of utilizing the old piping arrangements. When the first step of the rehabilitation program was carried out the two steam generators and that portion of the plant piping which was renewed with them was made heavy enough to handle the 300 lb. pressure. The new boilers recently installed are, therefore, designed to operate most economically at the higher pressure and the piping installed with them is designed to operate at 300 lb. pressure. It will not be possible, however, to obtain the economies incident to the higher pressure until the next or third step of the program with its battery of boilers and the remainder of the heavier piping is in operation.

The units are designed to use both low grade slack and run-of-mine coal. In the latter case it is run through a crusher before delivery to the pulverizers. It is also part of the specifications that any bituminous coal of reasonable quality available on the eastern market may be burned without difficulty and of course with distinct advantage from the purchasing agent's standpoint.

This ability to burn low grade coal is of particular importance in a railroad plant where the fines sifted from the run-of-mine coal used on locomotives is available in large quantities.



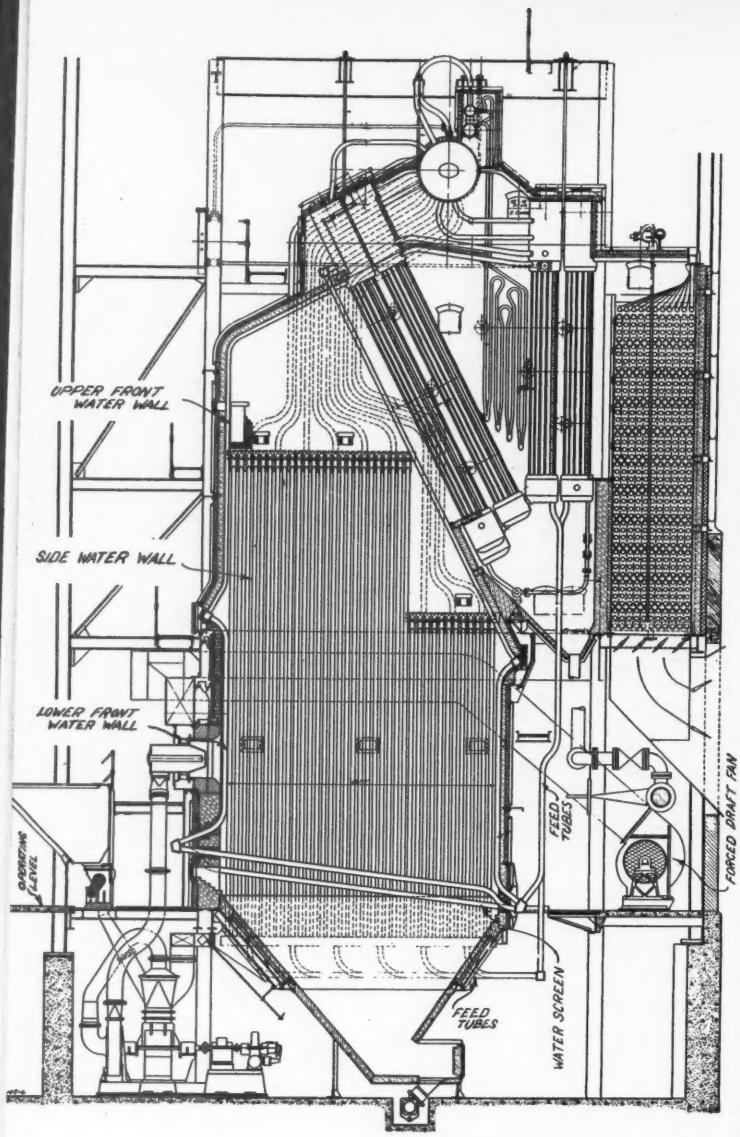


Fig. 2. Cross section through new boilers showing location of pulverizers and forced draft fan

The high volatile locomotive coals analyze approximately as follows:

Fixed carbon, per cent	53-55
Volatile, per cent	30-35
Ash, per cent	10
B.t.u. per lb.	13,500 (dry)
Sulphur, per cent	2.0-2.5
Ash softening temperature	2000° F

New Boilers Ordered About a Year Ago

The contract for the new units was placed slightly over a year ago with the Combustion Engineering Co. who sublet the contracts for other equipment. A list of the new equipment is shown herewith.

The automatic combustion control of the new units is provided by an extension of the existing Smoot system. The latter involves, or rather is associated with, a centralized control panel furnished by Republic Flow Meters Co.

From ash hopper to safety valve the new boilers are 71 ft. high or about the height of a seven story building. The furnace or combustion chamber is 19 ft. deep, 15 ft. wide and 40 ft. high or just about large enough to hold four ordinary box cars on end.

Details of construction are evident from the cross section of one of the new units as shown in Fig. 2. The mills for pulverizing the coal are located in the basement level 13 ft. below the operating floor. The two burners are 10 ft. above the operating floor on the first platform. The second platform is 19 ft. above the operating floor and provides access to the bottom of the economizers and the bottom of the Bigelow Hornsby boiler units proper. A third platform 30 ft. from the floor provides access to the observation doors and water wall headers, while the fourth platform 38 ft. above the floor permits access to the superheater cleanout doors and the top of the economizer. The fifth floor, 43 ft. up, carries the water column and gage glass and the water level is carried just 45 ft. 6 in. above the operating floor.

Water Cooled Furnaces

Furnace walls consist of the water wall tubes backed up with firebrick, insulation and a steel casing. The aggregate heating surface of the water wall tubes exposed to the furnace heat totals 3470 sq. ft. The firebrick wall in back of the front water wall tubes is hollow and air is drawn through it to be heated before going into the coal mills.

The boiler feed system of the old plant included closed feedwater heaters and cast iron economizers. The high percentage of make-up water never seriously affected the functioning of the old boilers as the incrusting solids were low, averaging 2 to 3½ grains per gallon and chemical treatment kept the scale to a minimum. Frequent analyses, however, showed that the make-up water was saturated with dissolved gases yet the corrosive action was apparently exhausted in the cast iron economizers because no corrosion ever became troublesome in any part of the old steam system. The fact that trouble in the form of latent dissolved gases was possible was not lost sight of, however, when steel tube economizers were selected for the new units. Owing to the necessity for keeping down the investment for this intermediate step in the rehabiliation program no change was made in the feedwater system except that the cast iron economizers were discarded with the old boilers, the installation of open heaters with deaerating equipment being a part of the final step in the procedure.

Protective Coating Applied to New Boiler Surfaces

Economizers were chosen instead of air preheaters or a combination of both because—first, the boiler proper would be protected from corrosion if trouble should occur before deaerating heaters could be installed and—second, in the event oil were used as a fuel, condensation and subsequent acid corrosion from flue gas in air preheaters at low off peak ratings would be avoided.

To combat the destructive action of the dissolved gases on the steam generating equipment the use of a protective coating was resorted to in the tubes, drums and economizers. It was expected that no severe pen-

alty would be paid during the short interim between completion of this step and ultimate installation of deaerating equipment. If corrosion did occur in spite of the protection the brunt of the damage would be in the tubes of the economizer which are readily replaceable.

These new boilers, although only in operation several months, have fully demonstrated their inherent flexibilty. It has been possible to vary the output at will from 20,000 lb. per hr. to over 150,000 lb. per hr. without difficulty and under automatic control the unit follows load fluctuations and maintains a uniform steam pressure within two pounds above or below the predetermined setting. The units are subject to rapid and large fluctuations in steam demand and it is essential that the boilers be able to follow these changes.

Ash disposal is effected by means of a vacuum system which discharges into a hopper at the top of the plant. Here the ash is mixed with water and sluiced away to the dump through a long cast iron line. This ash disposal system also has been extended to include the first two steam generators.

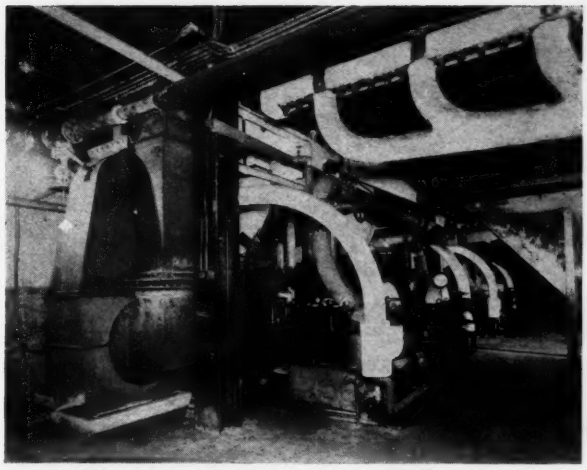


Fig. 3. Each boiler has two pulverizers, located in the basement below the operating level

Cottrell Electrostatic Precipitators Installed on New Boilers

Because of the proximity of the plant to the restricted residential districts of Greenwich and Riverside, Conn., the question of smoke and dust prevention has always been an important one and with such high capacity pulverized coal units as involved in the new installation, it was given special consideration.

With the steam generators installed in 1927 a system of mechanical cinder elimination was provided and had proved very successful, but the new units are equipped with Cottrell Electrostatic Precipitators. Direct current at 75,000 v. for this system is supplied by two transformers and two synchronous motor driven rectifiers. The power used is small, being about 5 kw-hr. per million cu. ft. of gas cleaned.

One precipitator is provided for each two boilers, and dampers are arranged so that all of the flue gas from two boilers may be passed through one precipitator if required. Cleaning is a matter of only a few

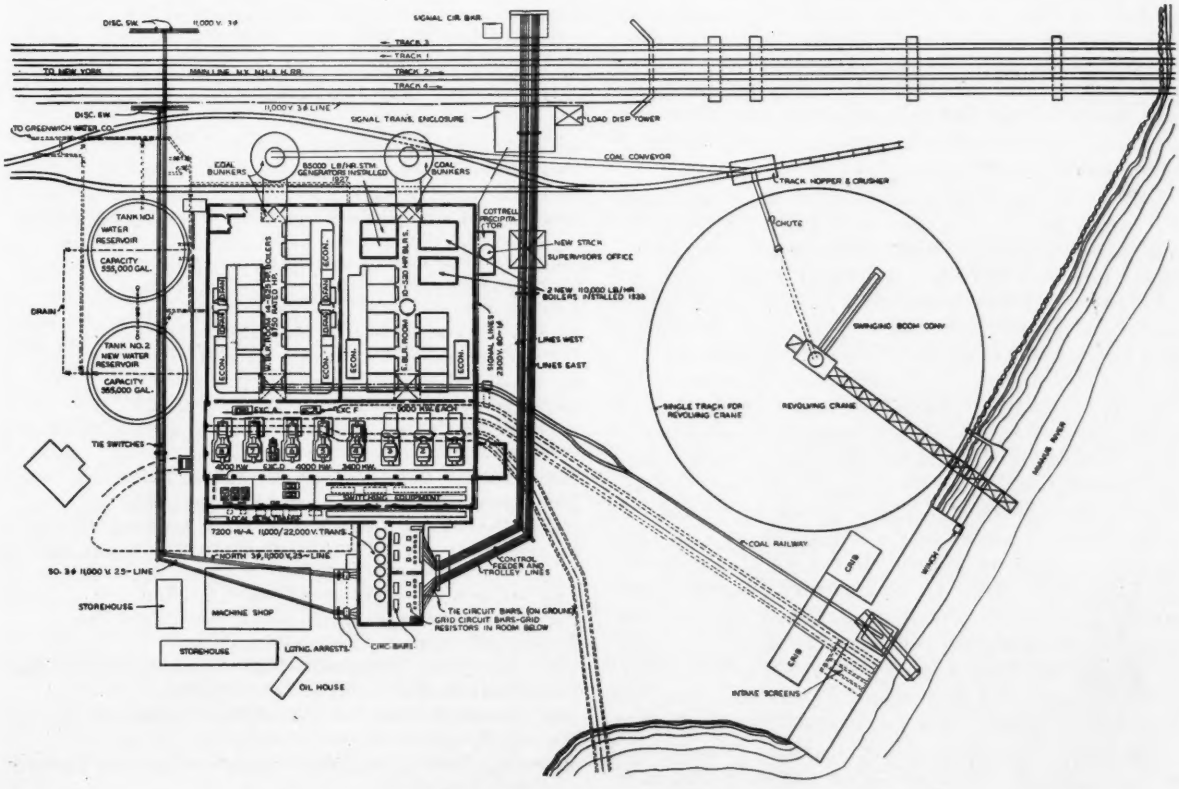


Fig. 4. Plan of station and property showing location of new boiler units

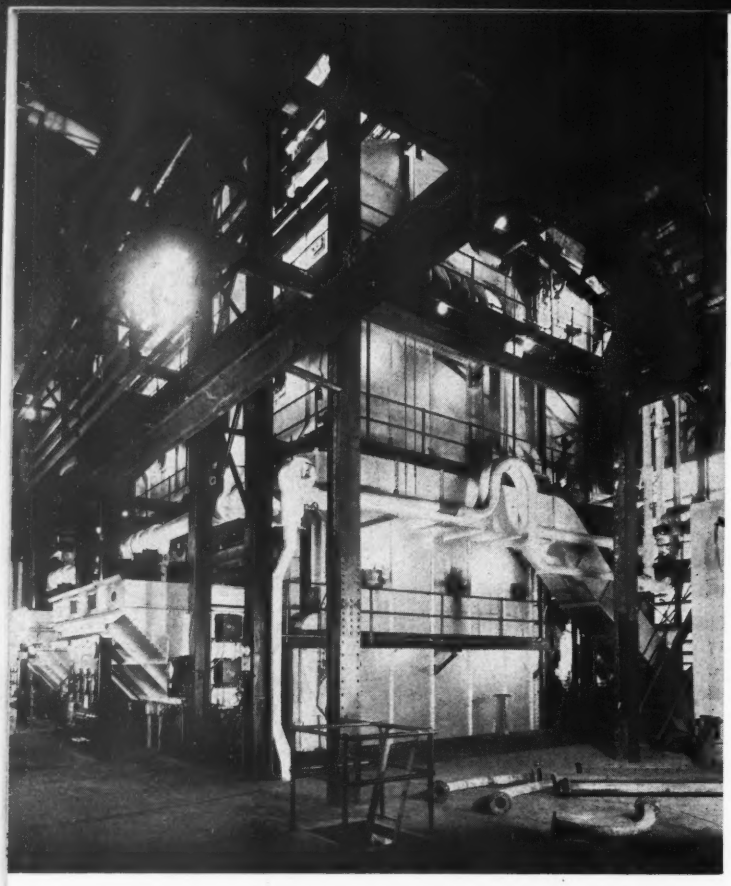


Fig. 5. General view of new boilers from operating floor level.

minutes and consists merely of reducing the voltage while motor driven scrapers are moved across the surface of the concrete precipitator plates.

The old Babcock & Wilcox boilers in the east boiler room are now out of the picture and the plant is operating with the new equipment which replaced them and a part of the old Bigelow Hornsby boilers in the west boiler room. The firm output of the station over a maximum hour using 4 of the old west boilers is approximately 25,000 kw.

As to the economies involved in the replacement of the old boilers with the new, full benefits of the concentrated high efficiency equipment cannot be obtained until the third and final step is completed and all of the old boilers replaced with new units operating at the new high pressure. The two new boilers with the two steam generators will produce about half of the steam necessary for operation of the plant. The new units will perform at an average overall efficiency of 85 per cent as against the 63 per cent efficiency of the old boilers of the east and west boiler rooms. This increase of better than 20 per cent efficiency for one-half of the plant alone will permit a saving of upwards of 15,000 t. of coal per year which, at the present price of coal, represents a cash saving of approximately $60,000. With coal prices stabilized so that lower grades of coal cost proportionately less, the fuel savings will be increased. Concentration of the steam generating equipment and elimination of excessive maintenance on the old boilers will result in considerable added savings in labor and maintenance expense.

The power generating and distribution equipment of the Cos Cob plant has been carefully and completely modernized and includes three practically new 9000 kw. single phase rating turbo generators with new power switching and controlling apparatus to handle the output of these machines. The five older generators are still in serviceable condition to function as standby sources of power generation.

The next rehabilitation step will include sufficient new boiler capacity to permit full utilization of this excellent equipment, the completion of the high pressure piping circuit, change over of the operating pressure from 200 to 300 lb., simplification of coal handling arrangement and concentration of the entire operating portion of the plant within the small confines of the original installation of 28 yr. ago.

The rehabilitation program described here is being carried out by the Engineering and the Mechanical Departments of the N. Y., N. H. & H. R. R. Co., under the direct supervision of C. L. Hartshorn, Engineer of Power Plants. The engineering problems, including study of the requirements and selection of equipment, as well as its arrangement, were handled by the railroad engineering staff. Messrs. Gibbs and Hill, Inc., of New York City were the consulting engineers who verified and detailed the work and also handled construction.

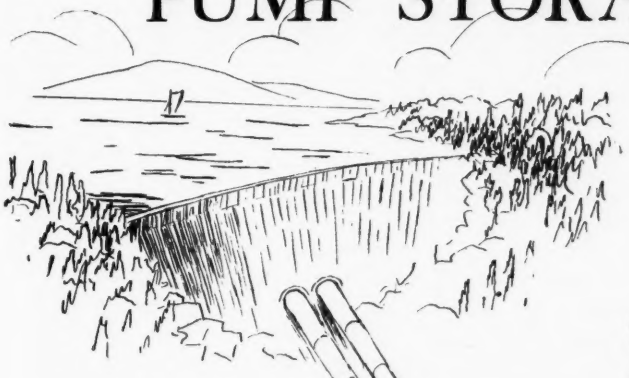
In concluding this description we desire to acknowledge our indebtedness to Mr. Hartshorn for supplying information on which this article is based and for courtesies extended in the collection of material.

PRINCIPAL DATA ON NEW BOILERS

Bigelow Hornsby boilers (2) with fusion welded drums, maximum rating 150,000 lb. per hr., 300 lb. pressure, boiler surface 7595 sq. ft. Combustion Engineering Co. water walls and slag screens 3470 sq. ft. Elesco superheater, Bigelow economizer 4850 sq. ft. efficiency at 110,000 lb., 85 per cent furnace volume, 7800 cu. ft. heat release at 125,000 lb. rating 21,200 B.t.u. per cu. ft., furnace gas temperature not in excess of 2000°F entering upper slag screen tubes.

Air Cooled Front Wall—American Arch Co.
Refractories—General Refractories Co.
Coal Feeders, 8—"Lopulco" Comb. Engineering Co.
Pulverizers, 4—"Lopulco" Comb. Engineering Co.
Coal Burners, 4 (Turbulent Type "R")—"Lopulco" Comb. Engineering Co.
Automatic Combustion Control—Smoot Engineering Corp.
Continuous Blowdown—Henszey De-Concentrator Co.
Feedwater Regulator—S. C.—The Swartwout Co.
Feedwater Treatment—Hall Laboratories Inc.
Water Columns—Reliance Gauge Column Co.
Gage Glasses—Paul B. Huyette Co., Inc.
Soot Blowers—Diamond Power Specialty Corp.
High Pressure Valves—Chapman Valve Mfg. Co.
Blowoff Valves—Edward Valve & Mfg. Co.
Safety Valves—Consolidated Ashcroft Han. Co.
Non-Return Valves—The Edward Valve and Mfg. Co.
Forced Draft Fans, 2 45,000 c.f.m.—B. F. Sturtevant Co.
Induced Draft Fans, 2 101,000 c.f.m., 500°F 9" Water, 221 hp.—American Blower Corp.
Fan Turbines, 4—Terry Steam Turbine Co., The.
Pulverizer Turbines, 4—Terry Steam Turbine Co., The.
Boiler Feed Pumps, 3—Ingersoll Rand Co.
Boiler Feed Pump Turbines, 3—Terry Steam Turbine Co., The.
Boiler Instruments—Republic Flow Meters Co.
Ash Removal System—Conveyors Corp. of America.
Fly Ash Precipitators—Cottrell-Research Corp.
Protective Coating for Boiler Surfaces—Apexior—Dampney Co. of America.

Couplings *for Hydroelectric* PUMP STORAGE PLANTS



Ingenious Coupling Devices Using Hydraulic Systems of Transmission Developed in Europe for Use in Pump Storage Plants. Units of As High as 30,000 hp. Capacity Have Been Built

PUMP STORAGE PLANTS in which surplus electric energy, at times of light load, is utilized to pump water to storage reservoirs, from which it can later be drawn for the production of further energy have now been constructed in several countries, notably in Europe. In some installations of this kind pumps driven by separate electric motors are provided, but more recently it has become the practice to set the pump in line with and arranged so that it can be driven from the main generating set. This eliminates special pump motors and saves space.

In such cases, however, it may be necessary to connect the pump during times of normal power generation, and, as the capacity may be large, and as it has to be coupled-up without shutting-down, the question of the type of clutch to be used raises interesting problems. In the earlier installations of this class, of comparatively small power, the ordinary type of friction clutch proved satisfactory and in Switzerland, Messrs. Escher Wyss, of Zurich, have successfully utilized mechanical clutches of this kind for pumps up to 1000 hp. running at 1000 r.p.m. With the introduction of the electro-magnetically operated friction clutch, matters were carried further and clutches transmitting as much as 10,000 hp. have been built.

In such large sizes, however, the appliances have not proved altogether satisfactory, the friction linings not standing up to their work unless lubricated, when there is a reduction of the coefficient of friction and consequent slipping. Mechanical clutches have also been built, using a number of conical friction surfaces, up to capacities of 27,000 hp. Although when the pumps are thrown into gear at full speed, the clutch at first transmits only about one third of the maximum power, the load gradually building up, experience shows that the friction surfaces wear rapidly.

In modern installations of large size, recourse has been had to hydraulic transmission clutches of the type first introduced nearly 30 yr. ago and developed by Föttinger for marine use. The principle of this type of transmitter is well known. The driving and driven shafts are in line, one carrying a pump impeller and the other a turbine runner. The pump and turbine are located inside a fixed housing which incorporates a guide chamber. The housing contains water which is circulated by the pump, flowing in a closed circuit and driving the turbine. The driven shaft starts up gradually. As employed in marine service the device is a speed changing device rather than a clutch, but from it, a simple hydraulic clutch has been developed for use in pump-storage plants. This consists merely of a casing containing an impeller mounted on the driving shaft and a turbine runner on the driven shaft. If the casing is filled with water, and it is assumed that the two shafts are revolving at equal speeds, the water will be relatively at rest. If now the driven shaft is loaded its speed will fall and a circulation of the water in the casing set in. The speed of this circulation will increase with the power transmitted, owing to the increasing slip. By making the clutch sufficiently large, the slip may be reduced to as little as 1 per cent but in many applications it is more economical to reduce capital costs by using a smaller clutch with a larger slip.

Whatever size of clutch is used with this arrangement, the slip represents a continuous loss of energy and for pump storage plants the arrangement has been modified by the incorporation of a mechanical clutch which is thrown into gear when the driven shaft has attained a suitable speed. Several arrangements of this kind have been developed but the one described here, using a friction clutch, was constructed by Messrs. Escher Wyss and has proved very satisfactory. The details as shown here were described in a recent number of "Engineering" of London from which the material presented here was abstracted. This development consists of a hydraulic transmission in combination with a mechanical clutch.

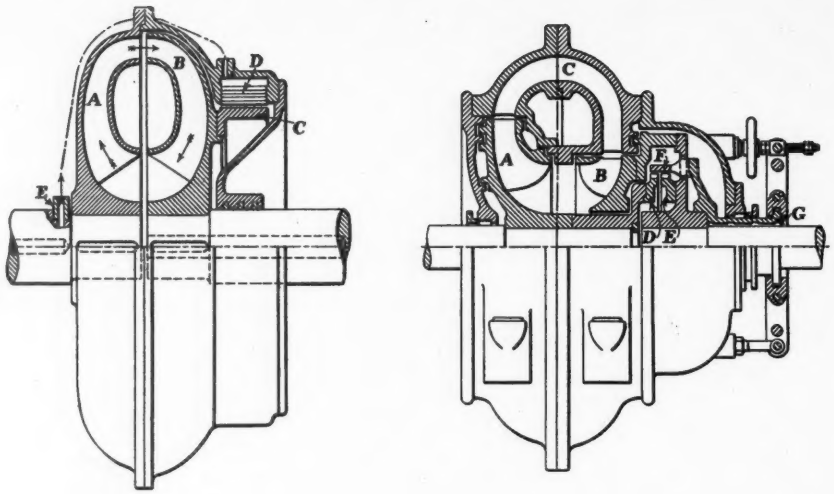


Fig. 1 and 2. Cross sections showing details and principles of coupling unit

Referring to the arrangement illustrated in Fig. 1, the hydraulic clutch with its impeller A and turbine rotor B, is shown at the left hand side.

A drum C attached to the rotor is acted on by a series of friction shoes actuated by pistons D, the cylinders of which are supplied with pressure water, by way of a connection E, from a passage through the center of the driving shaft. It is permissible to allow a slip of from 10 per cent to 15 per cent on the hydraulic clutch, which may consequently be made comparatively small. A slip of this order still allows the friction clutch to be thrown in without serious wear on the friction blocks. As the main drive is transmitted through the friction clutch, the operation of which depends on an outside supply of pressure water, the arrangement is not self-contained, and in order to eliminate dependence on an outside source of power, Messrs. Escher Wyss have introduced a transmission of this kind, incorporating a positive dog clutch. This is illustrated in Fig. 2.

In this case it is necessary that the speed of the pump shaft should be brought up to that of the prime mover before the mechanical clutch is engaged, and consequently the simple hydraulic clutch has been replaced by a coupling on the lines of the Föttinger transmitter. The fixed guide chamber C is retained and the relation between the impeller A and the runner B arranged so that equality of speed between the driving and driven shafts is attained when the power transmitted is that required to drive the pump when primed, but running light. When synchronism is reached, the mechanical clutch is thrown in. The clutch consists of two toothed rings, D and E, one secured to the impeller and the other to the driven shaft. A series of connecting dogs, F, are carried by a muff forming part of the sleeve G. This sleeve may be moved along the shaft by means of a

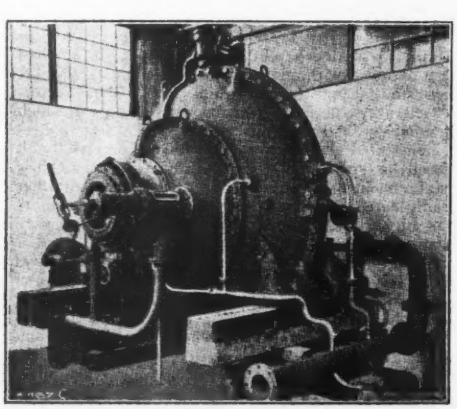


Fig. 3. The 18,000 hp. unit for the Schwarzenbach Power Station

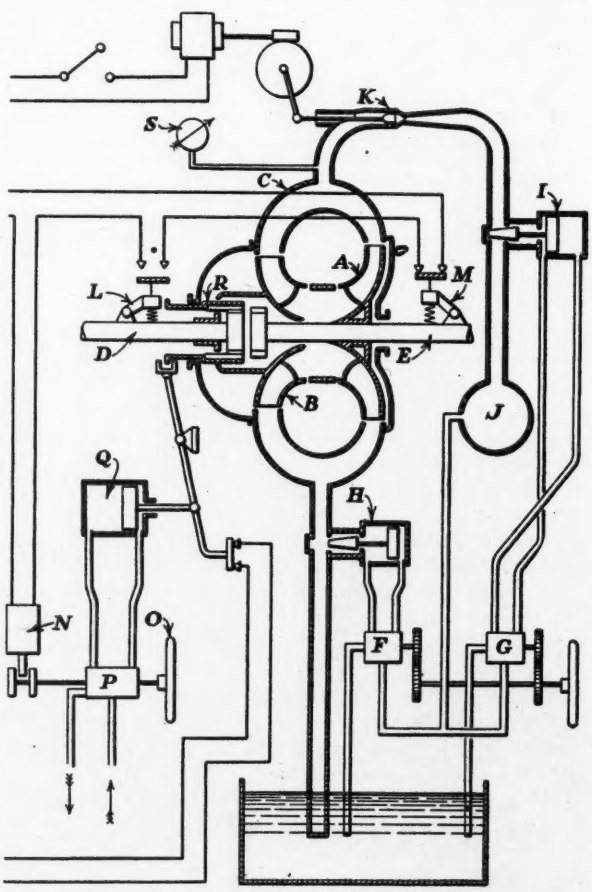


Fig. 4. Diagram showing complete system

swinging link operated by a screw and hand-wheel and by moving the sleeve inward the dogs enter between the teeth of the rings so that the arrangement practically forms a solid coupling. After connecting-up, the casing of the hydraulic clutch is emptied of water, so that the impeller and turbines run in air.

When developing this coupling, an experimental model was built, transmitting 200 hp. at 750 r.p.m. This operated in such a satisfactory manner that the firm proceeded to the construction of an 18,000-hp. unit running at 500 r.p.m., for the second storage-pump unit of the Schwarzenbach power station. This is illustrated in Fig. 3, while Fig. 4 is a diagram of the control arrangements. When the turbine is driving the generating set and no pumping is being done, the clutch impeller A, which is fixed to the driving shaft E, is running in air. When it is desired to start the pump, the two mechanically-coupled regulating valves F and G are opened by means of the handwheel shown. This closes the discharge valve H of the clutch casing C and opens the charging valve I. Pressure water for these operations is obtained from the pipe J. As the final speed of the driven member D depends on the proportions of the mixture of water and air in the casing, a synchronizing nozzle K is incorporated, which gives a final adjustment of the water supplied in terms of the speed of the main set. The driving and driven shafts carry centrifugally-operated switches, L and M, and when the shafts are rotating at equal speeds an electric circuit is completed through the solenoid N and releases the bolt of the handwheel O, by which the mechanical clutch is controlled. The valve P is then opened and pressure water supplied to the servo-motor cylinder Q, so that the operating lever is moved and the dogs on the muff R connect the two toothed clutches. The discharge valve H is then opened and the casing emptied. To uncouple, the casing is filled with water, in the way already described, and when the internal pressure, as read on the gage S, corresponds to synchronous speed, so that the drive is being taken by the hydraulic clutch, the muff R is withdrawn by supplying pressure water above the piston of the servo-motor cylinder Q.

The centrifugal switches L and M of Fig. 4, which have been introduced in order to simplify the explanation of the method of starting-up, are not actually used on the Schwarzenbach set. Their place is taken by a frequency converter driven from the pump shaft. When this machine has run up to such a speed that its frequency corresponds to that of the main generator, a circuit is closed which releases the valve P. The handwheels for operating the clutch, together with the switch controlling the valve K and the gage S, are mounted on a panel near the machine. In the view of the coupling given in Fig. 3, the filling, injection water and emptying pipes can be seen, as also can the servo-motor. The wheels are accessible by removing the cover and the whole coupling, in its working position, is carried on two rack rails so that it may be removed from its position between the pump and generating set.

The success of this type of coupling has led to it being adopted in the recently-completed Schluchsee and Waldeck power stations. The Schluchsee station contains four 27,000-hp. vertical sets and two of these are fitted with Escher Wyss couplings. The sets run at 333 r.p.m. A cross-section showing one of the units is given in Fig. 5. The coupling is shown at A between the main turbine B and the storage pump C. The axial load is carried by a thrust bearing fixed above the alternator D. Owing to the vertical arrangement of the set, the coupling is somewhat inaccessible and it has accordingly been arranged so that its main parts may be moved sideways on to a gallery which runs the length of the power station. It is indicated on the gallery by dotted lines in Fig. 5. In this position it can be handled by the power station crane. In internal construction the coupling is essentially similar to the

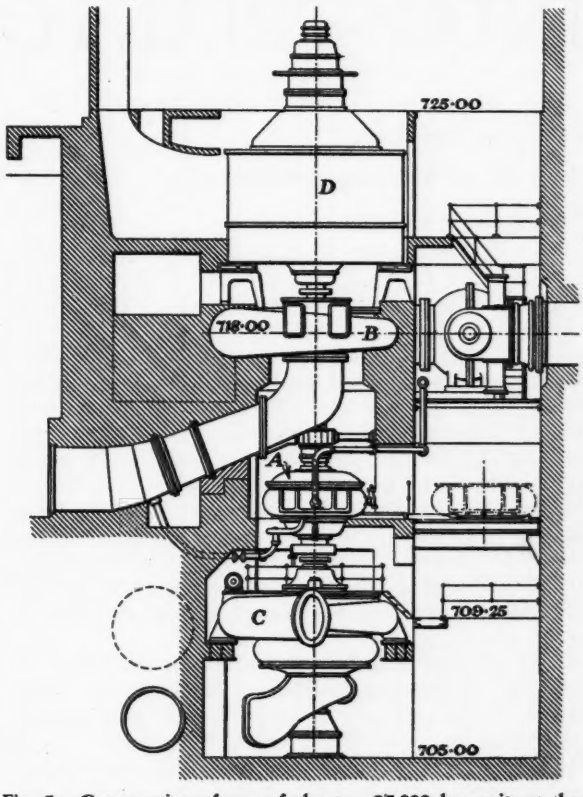


Fig. 5. Cross section of one of the two 27,000 hp. units at the Schluchsee Station

Schwarzenbach coupling, but considerably larger, the hydraulic part transmitting 10,000 hp. and the mechanical part 27,000 hp. at the comparatively slow speed of 333 r.p.m. The sleeve of the mechanical coupling is operated by an annular piston, set concentric with the driven shaft, instead of by an external servo-motor. The coupling is operated electrically and is controlled from a panel on the switchboard gallery.

The largest Escher Wyss pump-storage plant clutches so far manufactured are the four 30,000-hp. units for the Waldeck power station. These are of the horizontal type and run at 500 r.p.m. In general, they are of similar construction to the Schluchsee coupling, the muff being actuated by an internal annular servo-motor piston. The automatic control has been to some extent simplified, and instead of the charging valve and synchronizing nozzle there is a single regulating nozzle operated by a servo-motor. The valve controlling this servo-motor also operates the discharge valve. In practice the throwing-in of one of these couplings, from the beginning of the filing of the casing, takes about three-quarters of a minute.

Economy in the Generation *and* Use *of* INDUSTRIAL POWER *and* STEAM

By Linn Helander

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Kansas State College

Part I—Consideration of means for affecting economies when all power used by an industrial plant is generated locally in the form of by-product power and when some part of the power used is obtained from condensing units. In this part of the two-part serial article, a practical program for solving the preliminary engineering problems encountered in improving economy is definitely outlined, leaving for treatment in Part II a presentation of actual problems and their solutions.

WHETHER a given industrial plant, developing all of its power locally, generates that power exclusively as a by-product of process steam, in which case a condenser as such will not be employed in the power station, or whether it generates some part of its power with condensing units is an important consideration for one engaged in improving the overall economy of the plant; not as a criterion of economy attained or of inefficiencies present as it is sometimes thought to be, but as an index by which one may determine whether he should devote his immediate attention principally to the generation of steam and its use among the industrial processes or to the generation of power as well.

No plant that consumes steam can operate at or near the maximum of efficiency unless it has a condenser or its equivalent. In the case of an industrial plant that uses process steam, the condenser or condensers may be located in the power plant as adjuncts of the turbines; they may be located among the industrial processes as adjuncts, for example, of evaporators; or they may be located both in the power plant and among the industrial processes. Theoretically it does not matter whether the condensers are located at one point or another. Practically their point of location may be a matter of great importance.

Under certain conditions, flexibility and economy are attained by placing condensers both in the power plant and among the industrial processes; under other conditions the power plant condenser can be eliminated advantageously. In no case, however, is the complete absence of condensers from the power plant an indication in itself that a high order of heat economy has been attained for the industrial plant as a whole, even though it may give assurance that all power generated will be in the form of by-product power.

If the industrial processes consume the minimum amount of heat required to sustain them under the most favorable operating conditions producible; if, in addition, no amount of steam passes from a region of high pressure to one of low pressure through a reducing valve; if, further, no part of the heat in the exhaust steam from the turbine is wasted, then the absence of condensers in the power plant is an indication that the highest order of economy attainable practically has been reached. But if these conditions are not fulfilled in all respects, the absence of condensers from the power plant has no such significance.

Improvement Program Begins With Survey

To determine what order of economy is being attained in a given industrial plant, and to determine further what devices are available for improving that economy, one must investigate exhaustively the various processes to determine whether these as a whole as well as separately are performed economically. If the power plant operates condensing, i.e., in such a manner that some part of its exhaust heat is wasted, the investigator should study carefully the boiler room, the power generating station, and the industrial processes, i.e., every part of the plant that uses heat.

If the power plant operates non-condensing in such a manner that all of its exhaust heat is redistributed to industrial processes and no part is a waste, the investigator should devote his immediate attention principally to the boiler room and the industrial processes, for, under these conditions, the economy of the power generating station will be fixed approximately and known within narrow limits.

The first step in any investigation of an industrial plant to determine how economy in the use of fuel can be effected is to prepare what is commonly known as a heat balance diagram. This consists of a diagram showing the paths of flow of steam from the boiler to its various points of use, and its return as water to

the boiler. On this diagram, the rates of flow of steam and water under the various conditions to be considered, rates of energy output and of energy consumption, the properties of the steam and water passing any section, and whatever other data may be pertinent to the problems at hand should be placed.

From such a diagram as this, the experienced engineer can frequently discover by inspection alone where and how economies may be effected. Usually, however, a careful study of the diagram must be made. In addition, calculations which are sometimes involved must usually be made to test out the applicability of the various means of effecting economies that suggest themselves. An available energy balance diagram, such as was discussed in a previous series of articles*, will be found very helpful.

When all Power Generated Is in the Form of By-Product Power

When the power station of an industrial plant that generates all of its power locally operates in such a manner that its output is exclusively in the form of by-product power, all of the steam supplied to the power generating units being used subsequently in the form of bled and exhaust steam by the industrial processes, the means usually adopted for improving the economy of a central station generating room are not applicable. Raising the pressure and temperature of the steam supplied to the turbines will not in this case improve the fuel economy, nor will the fuel economy be improved by bleeding steam from lower pressure stages of the turbine to replace or supplement higher pressure steam used for heating feedwater or for processes.

This is usually explained by saying that since all the power generated is by-product power developed at a heat rate per kilowatt-hour little greater than the heat equivalent of a kilowatt-hour, no further improvement in the efficiency of power generation is obtainable. A more enlightening explanation is that the total hourly fuel-heat consumption of the plant in this case is very closely equal to the hourly heat consumption of the industrial processes divided by the boiler efficiency plus the power load in kilowatts times approximately 3600 B.t.u. divided by the boiler efficiency. Since in a given case the average power load times 3600 will be a fixed quantity, this explanation leads to the conclusion that for the case here being considered, improvement in the fuel economy of the plant can be realized only by reducing the heat consumption of the industrial processes and improving the efficiency of the boiler. No changes that leave these parts unaffected can affect therefore the fuel economy of the plant. It follows that the engineer when dealing with this case should devote his immediate attention to reducing the heat consumption of the industrial processes and to improving the efficiency of the boiler room.

Relation Between Fuel Savings and Process Heat Savings

Aside from the boiler, not only are the industrial processes the part to which the engineer should devote his immediate attention in his effort to reduce the fuel consumption where conditions are such that all power generated is in the form of by-product power, but in addition his reward for so doing will in general be greater and more easily attained than will be his reward for attending to the industrial processes in the case of a plant wherein some part of the power developed is generated on condensing units. In the latter case, fuel savings are approximately proportional to the savings in available energy and therefore relatively small where the available fraction of the heat conserved is small, as it is likely to be among the industrial processes. In the former case, fuel savings are directly proportional to the process heat conserved, regardless of the level of availability of this heat.

To illustrate the difference, the case of recovering condensate for use as boiler feedwater may be considered. If the plant is one that generates some part of its power on condensing units, the overall reduction in heat consumption consequent upon a return of previously wasted condensate to the boiler feed system will be only a fraction, in a case considered later, 25 per cent approximately, of the heat returned, assuming of course that bled steam is employed for heating the feedwater. In the case of a plant in which all power is generated in the form of by-product power, a similar recovery of condensate will reduce the overall heat consumption an amount equal to the heat returned. In the former case, the recovery of condensate may be, from the viewpoint of heat economy, relatively unimportant. In the latter case, it may be a matter of major importance.

Means for Improving Economy

In addition to recovering condensate and other forms of hot water, the following means for improving the economy of an industrial plant wherein all of the power generated is in the form of by-product power are available:

(1) Installing multiple effect evaporators to replace single effect evaporators, raising the pressure of the steam supplied to the evaporators if necessary. Up to the point that a condenser must be installed in the power plant, an elevation of the pressure of the bled or exhaust steam supplied by turbines to the evaporators will have no effect in itself upon the economy of the plant. The effect of installing multiple effect evaporators using bled or exhaust steam from turbines will be the same, under the conditions here being considered whether the pressure of the steam supplied to the evaporators is increased or not. The reduction in fuel consumption will be approximately proportional to the reduction in steam consumption.

(2) Bleeding steam from industrial process equipment, principally multiple effect evaporators, for heating feedwater, also for use in processes for which steam so bled is suitable. Since bleeding the turbine for feedwater heating under the conditions here being considered may be ineffective in reducing the fuel consumption of the plant, it may prove advisable in some cases to avoid bleeding the turbine for this purpose and instead to use steam bled from process equipment exclusively. In any event, if additional low pressure steam is to be employed for heating

* Distribution of Energy Charges in Industrial Plants, Power Plant Engineering, page 450, Oct. 1934 and page 522, Nov. 1934.

feedwater or for use in processes to replace higher pressure steam, that low pressure steam will have to be bled from process equipment to be effective in reducing the fuel consumption.

(3) Electrifying heat consuming processes where practicable. So long as all of the power being generated is in the form of by-product power and economies that may be effected will not alter this, electrical energy, unit for unit, may be employed to replace heat energy without adding appreciably to the fuel consumption of the plant. In some processes, electrical heating may prove more efficient than steam heating. Where that is the case, electrical energy might advantageously be used in place of steam.

(4) Using heat pumps of vapor compressors on evaporators, or to reclaim waste heat in hot water. Again the use of these apparatuses is contingent upon the ability of the power plant to continue its generation of by-product power exclusively. The use of an electrically driven heat pump on evaporators will reduce the demand for process steam and increase the demand for power, thus bringing into closer balance the load actually developed and the power potentially available as a by-product of the process steam. Less steam then will flow through the reducing valve and the economy of the plant will be improved. Similarly, heat pumps may be used to recover heat from waste hot water. Where electrical energy is cheap, as it is where it is generated exclusively as a by-product of process steam, this may prove profitable.

When Power Plant Operates Condensing

When the industrial power plant operates condensing, economy in the use of fuel can be realized, up to the point that a condenser is no longer required in the power plant, by any of the means usually adopted for improving the economy of a central station. Thus in this case economy in the use of fuel will be realized by improving the manner of heating the feedwater, for example, increasing the number of stages using bled or exhaust steam; by increasing the pressure and temperature of the steam supplied to the turbines, installing at the same time new turbines or revamping the old units so that these can use advantageously the steam supplied under the new conditions; by eliminating losses of heat wherever practicable, particularly heat with a high fraction of available energy; and, so far as practicable, by eliminating reducing valves and other devices that degrade energy unproductively. Where boiler steam or other forms of high pressure steam are supplied to processes through reducing valves, an effort should be made to replace this steam bled from the turbine at a pressure that approximates that at which the steam is to be used.

Among the processes themselves, efforts should be directed towards reducing the available energy consumption rather than the steam or heat consumption. In fact devices installed to reduce the steam consumption among the processes may actually increase the overall heat consumption of the plant, in the case here being considered, if they depend for their operativeness upon the employment of process steam at a pressure higher than that used previous to their installation.

An illustration of this would be the substitution of multiple effect evaporators for single effect evaporators under such conditions that the pressure of the steam supplied to the evaporators must be increased such an amount that the multiple effect evaporators consume more available energy, although less steam, than the single effect evaporators. Multiple effect evaporators can be used to replace single effect evaporators with assured fuel economy if they employ steam at no higher pressure than that used by the single effect evaporators, but if they demand higher pressure steam and the power plant operates condensing they should be investigated carefully before being installed.

Where steam can be bled from process apparatus at pressures below that of steam obtainable from turbines, as it sometimes can be from points between the effects of multiple effect evaporators, the use of steam so bled for heating water or for processes for which it is suited will be found a satisfactory means of reducing the available energy consumption of the plant and therefore its heat consumption. Where the heat supplied by steam to a process is consumed completely by that process; that is, where it is not redistributed through the agency of vapors produced to other processes, the steam supplying the heat should be delivered to the process at the lowest pressure suitable.

Where the heat is used subsequently in other processes, the temperature difference between the steam delivering the heat to the process and the medium carrying it to the next succeeding process should be as small as practicable. Reducing valves among the processes should be eliminated where possible; likewise radiation losses and leakage losses. Condensate should be recovered, but the thermal advantage in recovering condensate will not be so pronounced here as in the preceding case.

(To be concluded.)

Transformer Thaws Frozen Pipes

Frozen water pipes varying from ½ in. iron to 2 in. copper pipe and in lengths varying from twenty feet to over two hundred feet have been successfully and conveniently thawed by the use of special transformers originally designed for use in making the connections of the windings of large water wheel generators and similar equipment.

The special transformers used were built somewhat after the design of large bushing type current transformers. The primary winding is wound on circular punchings in four sections suitable for 125 v. 25 cycles per section. These sections of the primary winding can be connected in series, series parallel or parallel for use on 550, 440, 220 and 110 v. on 25 or 60 cycles.

The secondary connections are made to suit the job by threading cable through the opening, each turn giving a secondary voltage of 2.5 v. with the series connection of 550 v. primary and 2 volts for the 440, 220, and 110 v. connection. This gives very flexible arrangement, making it possible to obtain a suitable voltage to give any current value desired as for example ten turns to give 20 v., 200 amp. for thawing 40 ft. of ½ in. pipe in 3 min., ten turns to give 350 amp. for 40 ft. of 1¼ in. pipe thawed in five minutes, six turns to give 1200 amp. to thaw 200 ft. of 2 in. I. P. S. Copper pipe in one hour.

COMBUSTION CONTROL

Part IV. Details of Steam Pressure Regulators, Single and Double Acting, Full and Partial Stroke, Steam and Hydraulically Operated

STEAM PRESSURE REGULATORS are built in a variety of forms to meet the price and operating conditions of all types and sizes of plants. They are, of course, all actuated by steam pressure but the power for carrying out the control impulse varies widely. Some are operated by electricity, some by the steam pressure which they control and still others, the so-called hydraulic type, from a separate system of oil, air or water under pressure.

From a construction standpoint perhaps the simplest is the "on-and-off" electric control used on modern motor driven units built with integral fans. In this type a Bourdon gage element is arranged to make and break an electrical circuit. As the steam pressure drops below the lower limit, the stoker motor is started and operates until the steam pressure is up to maximum. The circuit is then broken and the motor stopped until the pressure again drops.

This is comparable to the action of a full stroke steam or hydraulic regulator often used to open and close the check, or uptake, dampers on small boilers. A steam operated regulator of this type, built by Julian d'Este is shown by Fig. 1 and the details of operation are given by the caption. In normal operation the damper is held open by the counterweight, and the piston is at the top of its stroke. When the pressure increases above that for which the spring is set, the valve is unseated and the steam pressure forces the piston down, closes the damper and checks the fire until the pressure drops to the point where the valve seats again. Then, under the action of the counterweight, the piston is returned to the top of its stroke, waste steam escaping through a V-notch in the plug. This is a single acting regulator, that is, power is developed in one direction only, the down stroke.

As the power developed by the operating cylinder is the product of the pressure acting and the net piston area it is plain that for low steam pressures a large operating cylinder would be necessary to obtain the necessary pull of say 100 lb. needed for a damper. In order, therefore, to make the operating power of the regulator independent of the steam pressure it is common practice to use the so-called hydraulic regulator,

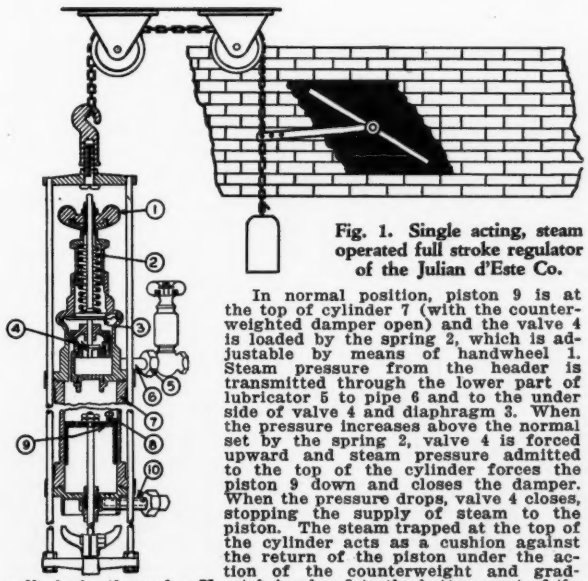


Fig. 1. Single acting, steam operated full stroke regulator of the Julian d'Este Co.

In normal position, piston 9 is at the top of cylinder 7 (with the counterweighted damper open) and the valve 4 is loaded by the spring 2, which is adjustable by means of handwheel 1. Steam pressure from the header is transmitted through the lower part of lubricator 5 to pipe 6 and to the under side of valve 4 and diaphragm 3. When the pressure increases above the normal set by the spring 2, valve 4 is forced upward and steam pressure admitted to the top of the cylinder forces the piston 9 down and closes the damper. When the pressure drops, valve 4 closes, stopping the supply of steam to the piston. The steam trapped at the top of the cylinder acts as a cushion against the return of the piston under the action of the counterweight and gradually leaks through a V notch in plug 8 to the bottom part of the cylinder and eventually to the drain through pipe 10.

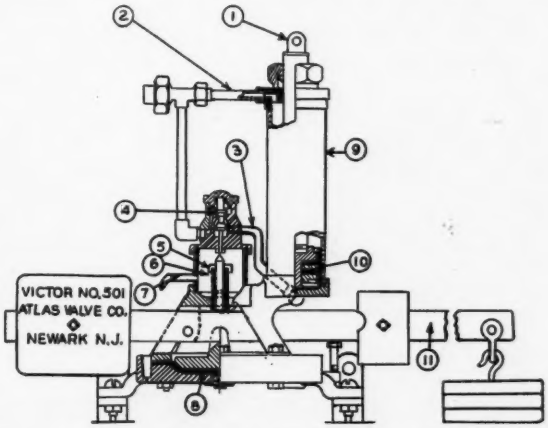


Fig. 2. Full stroke, double acting regulator of the Atlas Valve Co.

Piston stem 1 of this regulator is attached to the damper and is operated in both directions by the water pressure. The constant pressure which is admitted to the top of cylinder 9 through connection 2 forces piston 10 downward when the pilot valve 4 is closed and the discharge port in its stem, leading from the bottom side of the piston to the discharge chamber 6, is open. When the boiler pressure under diaphragm 8 is sufficient to raise lever 11, stem 5 closes this discharge port and opens pilot valve 4. Water then flows to the bottom of cylinder 9 through pipe 3, and, as the effective area on top of the piston is reduced by an amount equal to the cross-sectional area of the piston stem, the water pressure below forces it upward.

When the boiler pressure decreases, lever 11 will fall, valve stem 5 will fall, and the water will then flow from the bottom of cylinder 9 through pipe 3 and the pilot valve discharge port into chamber 6 and through pipe 7 to the drain. This permits the constant water pressure on top of the piston to force the piston downward.

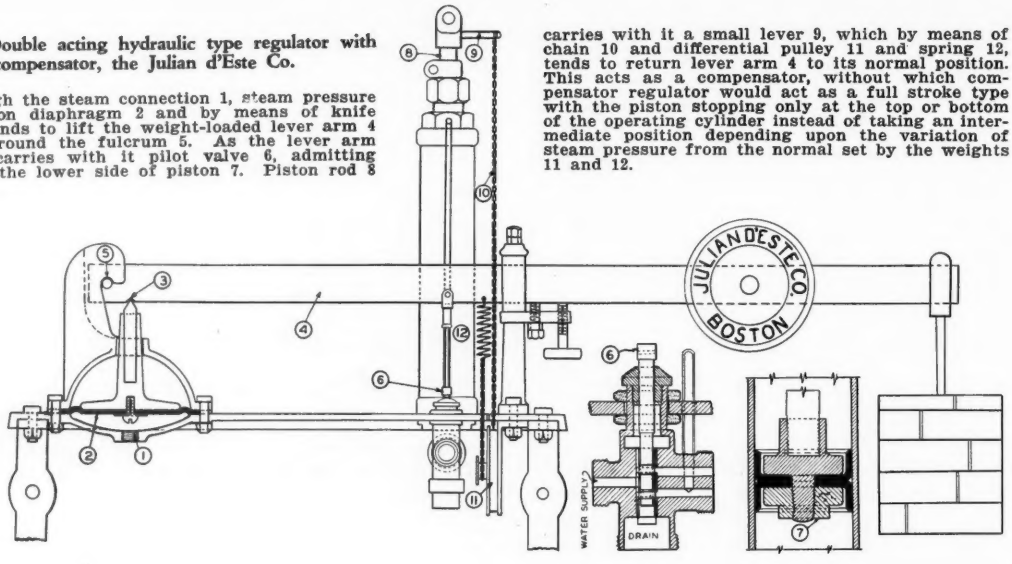


Fig. 3. Double acting hydraulic type regulator with compensator, the Julian d'Este Co.

Through the steam connection 1, steam pressure operates on diaphragm 2 and by means of knife edge 3, tends to lift the weight-loaded lever arm 4 pivoted around the fulcrum 5. As the lever arm rises it carries with it pilot valve 6, admitting water to the lower side of piston 7. Piston rod 8 carries with it a small lever 9, which by means of chain 10 and differential pulley 11 and spring 12, tends to return lever arm 4 to its normal position. This acts as a compensator, without which compensator regulator would act as a full stroke type with the piston stopping only at the top or bottom of the operating cylinder instead of taking an intermediate position depending upon the variation of steam pressure from the normal set by the weights 11 and 12.

in which the operating power is supplied from another system, air, water or oil under the necessary pressure.

A simple regulator of this type, made by the Atlas Valve Co., is shown by Fig. 2. Instead of acting on a spring loaded valve, the steam pressure in this regulator acts underneath a diaphragm and the force exerted is balanced by weights on a pivoted lever arm. Obviously by making the diaphragm large enough and the lever arm long enough the damper could be operated direct but it is customary to have the lever arm, which moves up or down as the steam pressure changes, move only a small pilot valve to control the flow of water to and from the damper operating cylinder. The action of the regulator is described in the caption. It is of the double acting type, that is, power is developed in both directions, on the upstroke and on the downstroke.

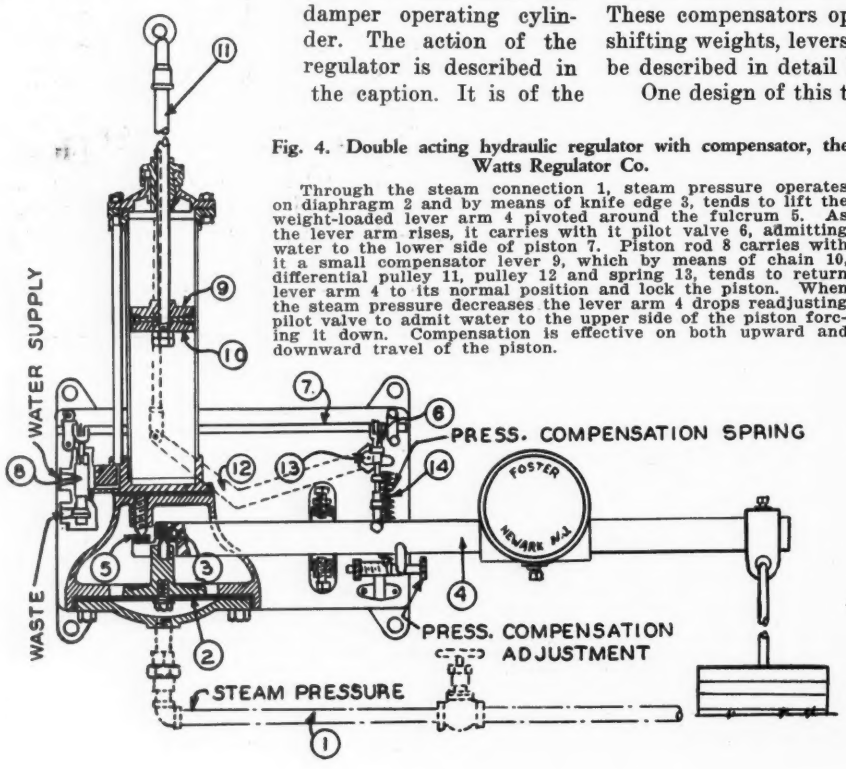


Fig. 4. Double acting hydraulic regulator with compensator, the Watts Regulator Co.

Through the steam connection 1, steam pressure operates on diaphragm 2 and by means of knife edge 3, tends to lift the weight-loaded lever arm 4 pivoted around the fulcrum 5. As the lever arm rises, it carries with it pilot valve 6, admitting water to the lower side of piston 7. Piston rod 8 carries with it a small compensator lever 9, which by means of chain 10, differential pulley 11, pulley 12 and spring 13, tends to return lever arm 4 to its normal position and lock the piston. When the steam pressure decreases the lever arm 4 drops readjusting pilot valve to admit water to the upper side of the piston forcing it down. Compensation is effective on both upward and downward travel of the piston.

Both of these regulators are of the full stroke type, meaning that the damper has only two fixed positions, fully closed and fully opened. With larger boilers it is often desirable to have a regulator which will hold the damper in an intermediate position which bears some relation to the variation of the steam pressure from the normal for which the regulator is set. To do this a compensator may be added, the general action of the compensator being to move the pilot valve back to its neutral position before the operating piston can take a full stroke for small variations of pressure. These compensators operate in several ways, springs, shifting weights, levers, adjustable orifices, etc., as will be described in detail later.

One design of this type, made by Julian d'Este Co., is shown by Fig. 3. In this regulator, steam acting on a diaphragm moves a small pilot valve which is of a different type from that shown by Fig. 2. The normal steam pressure may be adjusted by means of weights. As the steam pressure drops below this, the lever arm and pilot valve drop, admitting water to the bottom of the operating piston and connecting the top side to the drain. As the piston moves downward, tension on the compensator spring decreases and allows the lever arm to move up slightly. This returns the pilot valve to neutral position, and locks the piston. The position taken by the piston depends upon the variation of steam pressure from the normal set by

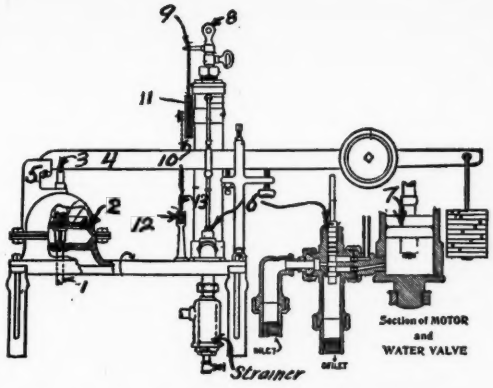


Fig. 5. Single acting, hydraulic regulator with compensator, the Foster Engineering Co.

Steam admitted through connection 1, acts upon diaphragm 2 and knife edge 3 on beam 4 pivoted on the fulcrum 5. An increased pressure lifts beam 4 and, through levers 6 and 7, the pilot valve 8 to connect the top of piston 9 to the drain. Under the action of a counterweight, piston 10 and piston rod 11 are pushed upward, at the same time decreasing the tension in compensator spring 14 through lever 12 pivoted around the point 13. A decrease in the spring tension causes the beam 4 to drop, returning pilot valve 8 to its neutral position and locking the piston into position. A decrease in pressure lowers pilot valve 8 and admits water pressure to the top of cylinder 9 and forces piston 10 downward.

the weights. As the regulator is double acting it may be connected to the damper either by cable, or by lever and rod, but the connection should be made in such a manner that when the piston is up the damper is closed.

In the regulator shown by Fig. 4, made by the Watts Regulator Co., the water passages and compensator are arranged somewhat differently but the piston still moves downward upon a decrease in pressure, so that the damper should also be closed when the piston is at the top of the cylinder.

A single acting regulator with a different arrangement of compensator spring and made by the Foster Engineering Co. is shown by Fig. 5. A decrease in steam pressure moves the pilot valve downward to admit water to the top of the cylinder and force it down. Increase in steam pressure relieves this pressure and the piston is returned by the action of the counterweight. The compensator spring can be adjusted by changing the effective length of the lever arm by which it is connected to the scale beam.

Figure 6 shows a regulator, made by Atwood & Morrill Co., in which the stroke of the operating lever O can be changed from 0 to 15 in. travel for a full stroke of the operating piston. This is done by shifting the block T along the sector M. With the damper closed the piston is at the top of the cylinder. As the steam pressure drops below normal the pilot valve drops, admitting pressure to the top of the operating piston. Compensation is by means of a spring, the tension of which is controlled by rod A.

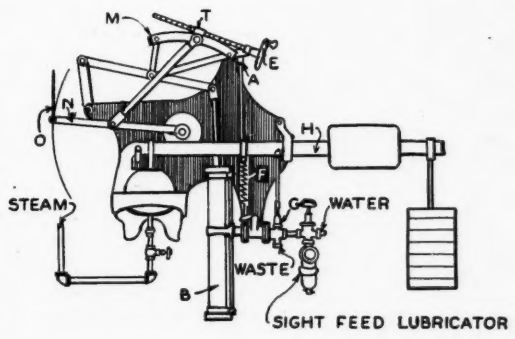
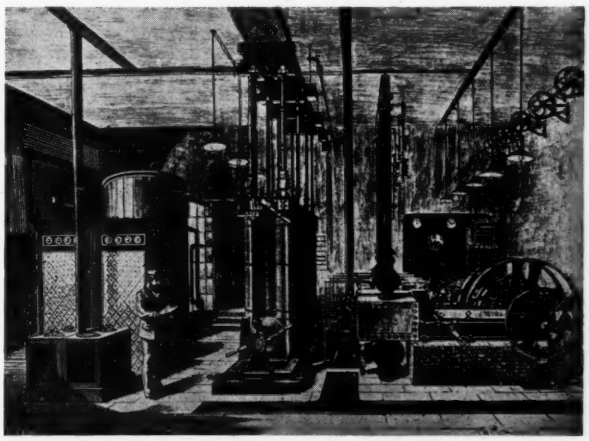


Fig. 6. Hydraulic type regulator with variable stroke, the Atwood & Morrill Co.

Steam is admitted under the diaphragm and an increase in pressure causes beam arm H to rise, opening pilot valve G to the top of hydraulic cylinder B. This causes lever C to travel downward, carrying with it lever arm N connected by cable O to the damper. As C travels downward, compensator lever A travels upward, increasing the tension of spring F and returning beam H and pilot valve G to normal. The stroke of N is regulated by means of the handwheel E and may be changed from 0 to 15 in., while the stroke of hydraulic cylinder B remains at 15 in. Lever N takes a full stroke when the block T is at the left end of sector M. When T is at the right end of the sector, N remains stationary.

Europe's First Central Station

LAST FALL Europe celebrated the 50th anniversary of the first central station, opened on Sept. 13, 1884. The new plant, built by the German Edison Co., a forerunner of Allgemeine Elektricitats-Gesellschaft, was located in the Friedrich-Strasse, Berlin. An illustration reproduced through the courtesy of AEG Progress shows the engine room with four horizontal steam engines each driving a generator rated at 450, 16 candle-power lamps and a fifth unit rated at 6 arc-



The engine room of Europe's first central station

lamps. There were three boilers with a heating surface of about 1000 sq. ft. each.

This system of rating the generators by the number of lights extended even to the ammeters which were calibrated in 16 candle-power units. A single voltmeter served the entire station and was arranged so that it could be connected to any generator or to the main bus. Branch fuses protected the distribution system. Meters were of the electrolytic type which measured current by the weight of zinc precipitated or dissolved. Oscar von Miller, the famous German engineer, who died recently, described the station before the Berlin Electrical Society March 24, 1885.

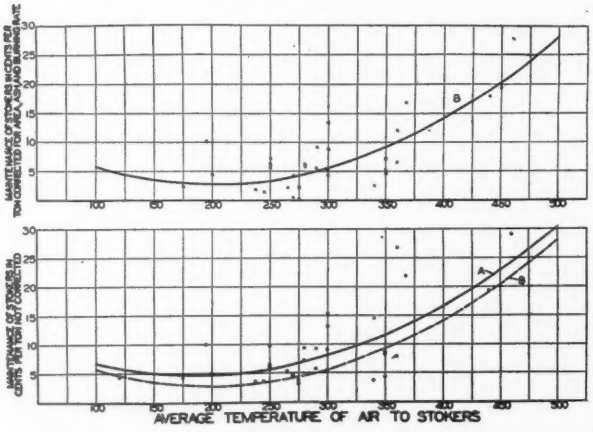
Economics of Preheated Air *for* Stokers

Study of operating data presented before the A.S.M.E. shows that underfeed stoker maintenance costs place upper limit of about 300 to 350 deg. F. on preheated air. By Robert E. Dillon and Melvin D. Engle, the Edison Electric Illuminating Co., Boston, Mass.

DEVELOPMENT of the regenerative cycle, the operation of boilers at higher and higher outputs and the adoption of higher pressures and the single-pass boiler, have reduced the heat reclaiming possibilities of the economizer and have resulted in the installation of air heaters for most high-efficiency steam-generating units.

Highly preheated air, however, has increased the maintenance of underfeed stokers. To determine to what extent stoker maintenance is a function of air temperature, maintenance data from 33 operating companies operating 122 underfeed stokers supplied with hot air were studied. The data cover stokers operating with average air temperatures varying from 120 to 460 deg. F., maximum air temperature as high as 660 deg. F. and 475 stoker-years of operation.

Maintenance was plotted against average air temperature and a fairly satisfactory relation, shown by Curve A, found. In order to remove the influence of other variables affecting maintenance, stoker maintenance was plotted against other operating and design factors and each corrected for temperature. From this data it was found that the variables, other than average air temperature, that most seriously affect maintenance are: Area of stoker; average coal burned in pounds per square feet per hour; percentage of ash in the coal burned. The data were corrected for these three variables, and a new curve, B, of maintenance vs. average air temperature was obtained with some of the influence of these three variables removed.



Corrected (B) and uncorrected (A) curves showing the influence of average air temperature on the maintenance cost of underfeed stokers

From this corrected curve, B, the following conclusion can be drawn: Up to 300 deg. F., the preheating of the air supplied to underfeed stokers does not seem to increase maintenance above reasonable figures, but above 300 or 350 deg. F., there is a sharp increase in maintenance with increase in air temperature. This means that for underfeed-stoker installations, the boiler, economizer, and air heater should be so proportioned as to keep the average temperature of the air supplied down to about 300 deg. F., unless abnormally high stoker maintenance can be countenanced for other advantages peculiar to the installation.

Methods to Reduce Maintenance

For the benefit of those who have hot-air stokers installed, a study of the data obtained has been made to find the changes made and operating methods employed by the various companies to reduce stoker maintenance. Some of these which follow may be applicable to installations.

Many of the companies have found that the use of the so-called "thin tuyere" reduces maintenance. These tuyeres are a little over one-half as thick as the standard tuyere and have air openings and cooling ribs so located as to maintain a lower tuyere temperature than is possible with the standard tuyere.

Many companies have reduced the number of pushers originally installed. The pushers removed are replaced with a dead plate designed for the particular type of stoker.

With hot-air stokers every attempt possible should be made to seal off the retorts and cause all air to be delivered through the tuyeres. Hot air coming through the retorts causes serious burn-outs.

Carrying the ashes higher in the clinker pit reduces extension-grate, clinker-grinder, and wall maintenance and maintains a more uniform fuel bed and lower combustible loss in the ashes.

Use of higher excess air, by carrying a thinner fuel bed, quite often results in lower overall cost of generating steam.

Finding of the correct fuel-bed shape, by the proper pusher motion, for each type of coal burned, results in lower operating costs, higher capacity, and fewer operating difficulties.

Careful adjustment of pusher motion across the width of the stoker results in more uniform fires and consequent advantages.

For the lower-air-temperature installations, spray lubrication of the operating mechanisms under the stoker may show surprisingly beneficial results.

Water sprays turned on periodically under the stoker, or water admitted through the nose of certain tuyeres at times, are used to crack off the slag which accumulates on the tuyeres of hot-air stokers.

Keeping of a cumulative, graphic record of maintenance and steam output or coal burned for each

stoker over a long period of time helps in pinning down the particular stokers showing high maintenance. Two stokers, apparently duplicates, may show wide variation in maintenance costs.

Low-alloy cast-iron stoker parts have been tried, but so far no one has shown that the higher cost of the alloy parts is economically justified. Good, sound castings, however, seem to help maintain low maintenance costs.

From curve B it can be seen that increasing the air temperature from 350 to 400 deg. F. will result in about 5 cents per ton increase in stoker maintenance. Since 50 deg. F. rise in air temperature represents about one per cent in boiler-room efficiency, for $5 per ton coal, the increase in stoker maintenance would absorb all of the saving in coal and no savings would be available to pay the fixed charges on the cost of the larger air heater. Furthermore, higher stoker maintenance indicates a lower boiler availability, and a larger air heater would be a losing proposition.

Chain Grate Stokers

Maintenance data were also obtained from seven companies operating 77 chain-grate stokers supplied with hot air varying in average temperature from 100 to 375 deg. F. The data represented 441 stoker years of operation. A plot of maintenance against air temperature gave nothing from which logical conclusion could be drawn. The same might also have been true for underfeed stokers had it not been possible to obtain data on stokers operating with average temperatures about 375 deg. F.

Table 1 gives the limit for the data obtained for both the chain grate and underfeed stokers. A study of this table shows the interesting facts that chain-grate stokers supplied with hot air and burning the types of fuel for which they are suited can match the underfeed stoker in coal-burning capacity in pounds per square foot per hour and apparently operate with lower maintenance cost.

Tabulation of Data on Both Types of Stokers

	Chain Grate Stokers	Underfeed Stokers
Number of companies	7	33
Number of stokers	77	122
Stoker years represented	441	475
Width	7'9" to 24'0"	7'6" to 30'0"
Length	15'0" to 22'9"	10'0" to 22'6¾"
Area in sq. ft.	155 to 528	75 to 611
Avg. air temperature, F.	100 to 375	120 to 460
Max. air temperature, F.	100 to 500	100 to 600
Excess air, per cent	20 to 50	20 to 70
Max. coal burned (lb. per sq. ft. per hr.)	36.8 to 72	21 to 75
Avg. coal burned, lb.	25.8 to 47	17 to 50
Moisture in coal, per cent	10 to 21	0.4 to 14.52
Volatile in coal, per cent	1.76 to 33.46	15.5 to 40.7
Ash in coal, per cent	6.00 to 14.70	4.3 to 14.33
Fusion temperature of ash, F.	2000 to 2400	2050 to 2900
Maintenance in cents per ton of coal burned	0.4 to 6.8	3.17 to 29.2

Report of the National Industrial Conference Board, Inc., shows that employment for December, 1934, was better both as to weekly hours and weekly pay than for November. Also compared to December, 1933, employment increased 3.1 per cent, hours worked for week increased 3.6 per cent, average hourly earnings rose 7.8 per cent and weekly earnings 11.5 per cent. Cost of living rose, however, so that the purchasing power of weekly earnings rose only 6.6 per cent.

Accident Lessons

A driver stopped in the company garage to replace a badly worn tire. Without deflating it, he loosened the lug nuts and removed tire and rim. He put the tire on the floor and was removing air valve to deflate it, when the rim collapsed and the inner tube, carrying approximately 60 lb. pressure to the square inch, exploded. The driver, who was sitting on the tire, was hurled six feet into the air. His left arm was broken in two places by the force of the rim. Investigation showed that the rim was not in good condition when the tire was placed on it. The locking device did not catch properly.

After that accident, his company issued this order: "Rims that do not lock properly shall not be used under any circumstances." A further precaution is the deflation of a tire before removing it from the wheel.

The maintenance department lineman was pulling in the slack in a street light line which was not alive. He was seated on the cross arm of the pole, and when he rose from this position and attempted to step across a live 2300-volt line, located on the center pins of the cross arm, his foot slipped and he fell across the live wires. Investigation showed that the protective equipment was in the truck, parked near the base of the pole. This accident, which resulted in a fatality, was ascribed to absolute disregard of instructions. While the workman was partly at fault, it was said, the line foreman also was responsible because he failed to insist that the victim make use of the rubber protective equipment.

Another accident involving the failure to use protective equipment: The lineman killed had worked more than thirty years on hot lines with a splendid safety record, and as far as was known at the time of the injury, was in splendid physical condition. While transferring wires from an old pole to a new one, the victim apparently reached for a "come along" and his arms came in contact with the lead of a live primary, while the right side of his abdomen touched the metal jumper clamp of the neutral primary. The safety rubber equipment was found at the base of the pole on which he had been working. It had not been used.

Under normal conditions, four men could have moved this coke conveyor across the yard. Footing, however, was uncertain. The ground was covered with snow and ice. The machine began to slide, and, as the four tried to hold it back, it ran over the foot of one of the men. He suffered a fracture of the great toe. Proper supervision would have assured the spreading of sand or ashes over the ice to prevent slipping and the presence of enough labor on the job to do it properly.

A cheap and good, heavy current resistor can be made by folding wire netting up and down over iron rods supported by insulators. Galvanized iron wire (No. 19 B. & S.) netting of 1 in. mesh and 12 in. wide has a resistance of approximately 0.005 ohms per yard and will carry 100 amp.

INSTRUMENTS *as* Practical Aids *to* Plant Operation

Good Instruments and a Good Engineer Makes a Good Combination to Ferret Out Hidden Leaks. By Ray B. Wolf

COMPLETE INSTRUMENTATION for power services is seldom warranted in small plants that furnish one or possibly two services and process or manufacture one commodity. The monthly water, light, power and fuel bills and the amount of commodity handled or processed, when reduced to a unit basis, will give a very good operating check, when compared to previous operations, provided a simple but good system of logging such data is kept.

When plants consist of two or more departments that handle one or more commodities in each and the power plant must furnish many different kinds of services such as power, light, water, steam, gas, air, refrigeration, etc., the actual charges to be made for each department and each service becomes a complex matter. Dependable and accurate instruments are indispensable in a case of this kind if anything like a correct charge is to be made. The accounting office in most cases turn to the engineering department for a periodic distribution report for all the power plant services furnished the various departments, these reports may cover a seasonal period, a monthly period or even a shorter period, depending on the rapidity of changes and the value of the services. Unless the power plant has the necessary instruments to measure the services consumed or distributed to the departments, it must calculate or assume these amounts and at best computations are lengthy and subject to errors due to unknown factors and the best assumptions are only a good guess.

In the following paragraphs it will be shown that, aside from the fact that good instruments used correctly and regularly help to operate a plant in the most economical way, they point the way to improvements in layout and in operations that make them invaluable. The power plant of a large and modern dairy (which besides handling market milk and cream, process and manufacture many different by-products and operate an ice plant, a laundry, paint shop, body-building shop, maintenance shop and allied services) is equipped with a complete line of control devices, recording and measuring instruments, many of which at the time of installation were innovations in the dairy industry.

Large and consistent savings were made by a thorough study of load characteristics furnished by charts and readings from the installed instruments and the investment in these practical tools has proved profitable to the management.

The steam charts shown are actual charts taken from the record file and impressed during normal operating periods and are only a part of the total

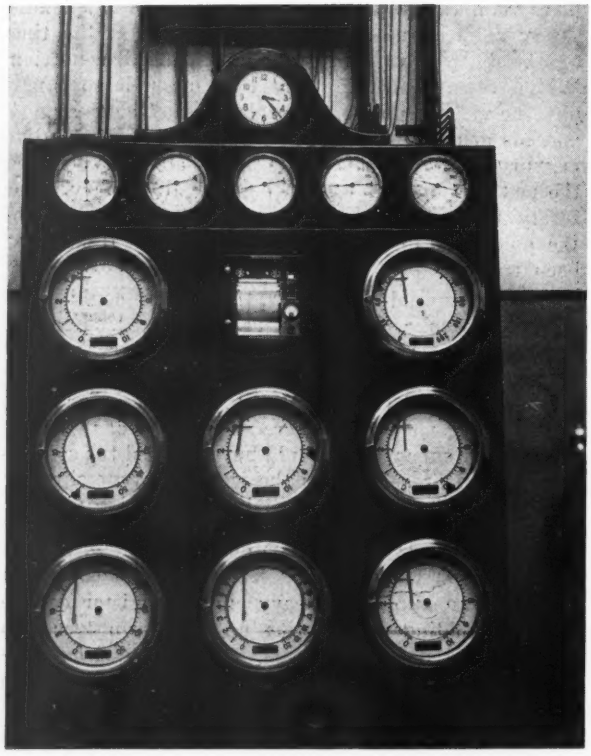


Fig. 1. The main gage board

Under the Telechron clock, are the indicating gages which are, left to right, the boiler pressure, the exhaust pressure, the heating system vacuum, the city water and air pressure gages, respectively. The rest are all flow meters that indicate, record and totalize, excepting the second instrument in the row beneath the indicating gages. This instrument is a CO_2 and flue gas temperature recorder. The others are, reading from left to right, starting in the second row from the top, for measuring the main steam flow from the boiler and the air flow from the air compressors.

In the third row are the process steam, boiler feed water supply and ice water services, respectively, and in the bottom row are the service steam flow, the engine steam flow and the hot and cold water services respectively. The ice water meter can be switched to any of three separate service lines, the hot and cold water meter to any of seven separate service lines which include heating water, cooling tower water and ammonia condenser water. The engine meter is valved for each of the three engines and the service steam meter is valved for two separate services.

Lines leading to the meters can be seen above the gage board and the bottom of the ammonia gage board can be seen at the top of the photograph. The flow meters are of great value in checking the sustained performance of the pumps and immediately indicate any reduction in flow due to wear, obstructions in the line or impeller or other causes and indicate the time the pumps are put in service and the length of time of operation. Some of the gages are two pen instruments, measuring besides the flow the pressure in the line on the main steam flow, air flow and water flow meters, and on the feed water meter the temperature is measured.

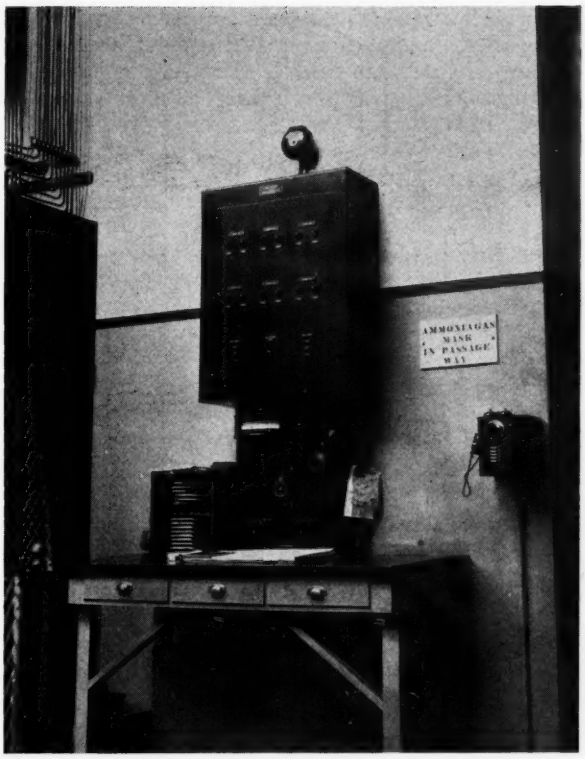


Fig. 2. Shows the log desk with the main gage board on the left and the inter-plant telephone on the right

Just above the log book is an electrical temperature indicating instrument with 37 stations. The activating principle is the thermocouple. It indicates all the important temperatures which are periodically logged, that are required to operate the plant at its most economical point and include the temperatures of ammonia liquid and gas, wet and dry bulb atmospheric, hot, tower and ice water, both outgoing and return, brine and cold rooms. It can be readily seen that the pertinent data from the log sheet coupled with the flow meter totals gives a constant check on performance. To use the instrument to indicate all the stations and log them on the sheet takes 5 min. of the engineer's time. To actually take the shortest route of the points covered by the instrument and mark down and log the temperatures takes 30 min. time. As the temperatures are partially logged every hour and all logged every 2 hr., the instrument is a large time saver, allowing the operator to devote more attention to other matters in the engine room.

Above the thermometer set is an answer board, a companion to a similar call board on the third floor of the milk plant in another building. It covers a set of six services used in the milk plant and includes three units for hot water and three units for cooling water. In operation the board acts as follows: With all services off, a green lamp burns dim on the off position on all six points. The milk plant operator desiring a service, say, hot water on No. 1 unit, presses a switch on his board to the "on" position, this causes a red light to burn bright, the green light goes out and a large indicator light atop the board burns bright.

The engine room board where the green lamps were dim on the off position, now shows a bright red light on the on position and a bell above the board rings. The engineer presses the button on the motor starter of the hot water pump in No. 1 service and the increased pressure in the discharge line of the pump trips a relay which causes the bright lamp to burn dim and stops the ringing of the bell. In the milk plant again, we find that the bright light here too has gone dim and the light above the instrument is out. The same procedure takes place for all the services but in addition on the cooling water service where both cooling tower water and ice water are needed, both pumps must be started to operate the mechanism. In taking a service off, the reverse takes place.

In the engine room the bright green lamp over the off position burns and the bell rings till the pump is shut down, when the bright light goes dim. This instrument acts as a very alert policeman in that it requires immediate attention from the engineer on watch and the correct pumps must be started. It will also indicate any trouble in the line or in the pumps due to faulty operation or lack of water.

services rendered, however, they clearly show the result of planned control. Chart 1, Fig. 4, is from a flow meter of the orifice type which measures the flow of 110 lb. steam to open hot water heaters. The flow of steam is controlled through an electric motor operated valve by means of a recording instrument actuated by a bulb immersed in the water. The chart shows an erratic demand with wide fluctuations during the operating period and a total consumption for the day of 25,480 lb. of steam.

Such operation as revealed by the chart was considered inconsistent with good practice and the thermostat bulb was removed from the line and put into the tank with the result as shown in Chart 2. While the actual heating load was the same the consumption dropped to 22,050 lb. of steam for the day. The charts are divided into three distinct periods, the milk heating, the cream heating and the by-product heating periods and by reading the chart integrator after every period, the amount of steam used for that particular service can be determined.

A part of the engine room equipment consists of two ammonia compressors driven by electric motors and three Corliss steam engine driven ammonia compressors. The engines together with the boiler feed pump exhaust into the low pressure main where a pressure of 4 lb. is maintained. This main supplies steam for building heating, for the boiler feed water heater and for heating general service hot water. As an economical consideration the engines are run in

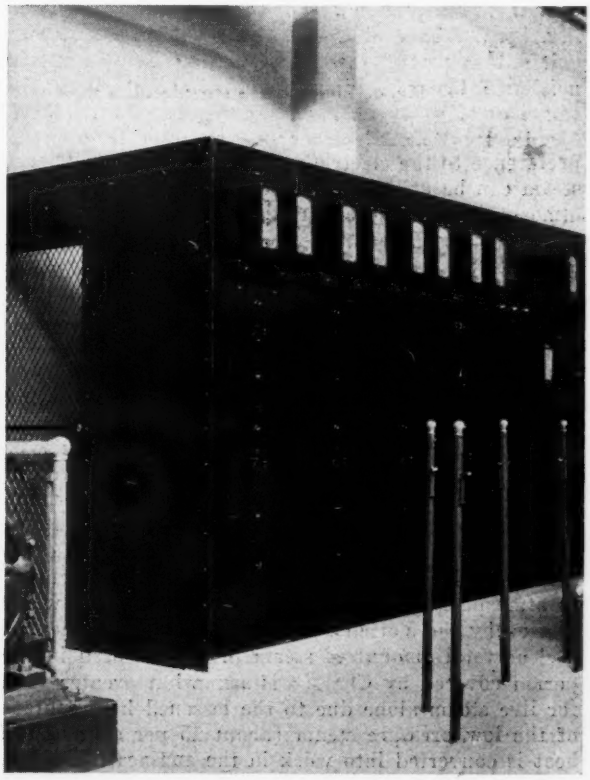


Fig. 3. A section of the dead front type main distributing panel board

A small red bull's eye is above every disconnect to indicate the position of the switch and the condition of the fuses from a distance. A watthour meter is installed for each main disconnect and measures the current to each major department. There is a test block below each meter for checking. On the fifth panel on the extreme right of the picture is a recording voltmeter and the three lamps above this meter are on the ground detecting system. All three lamps burn dim excepting when a short to ground occurs in any circuit in the entire plant, when one of the lamps will go out and the other two burn bright. This system is very sensitive and will indicate even light grounds such as damp insulation in conduits and on motor terminals. By a process of elimination the offending circuit is quickly determined when a short to ground occurs.

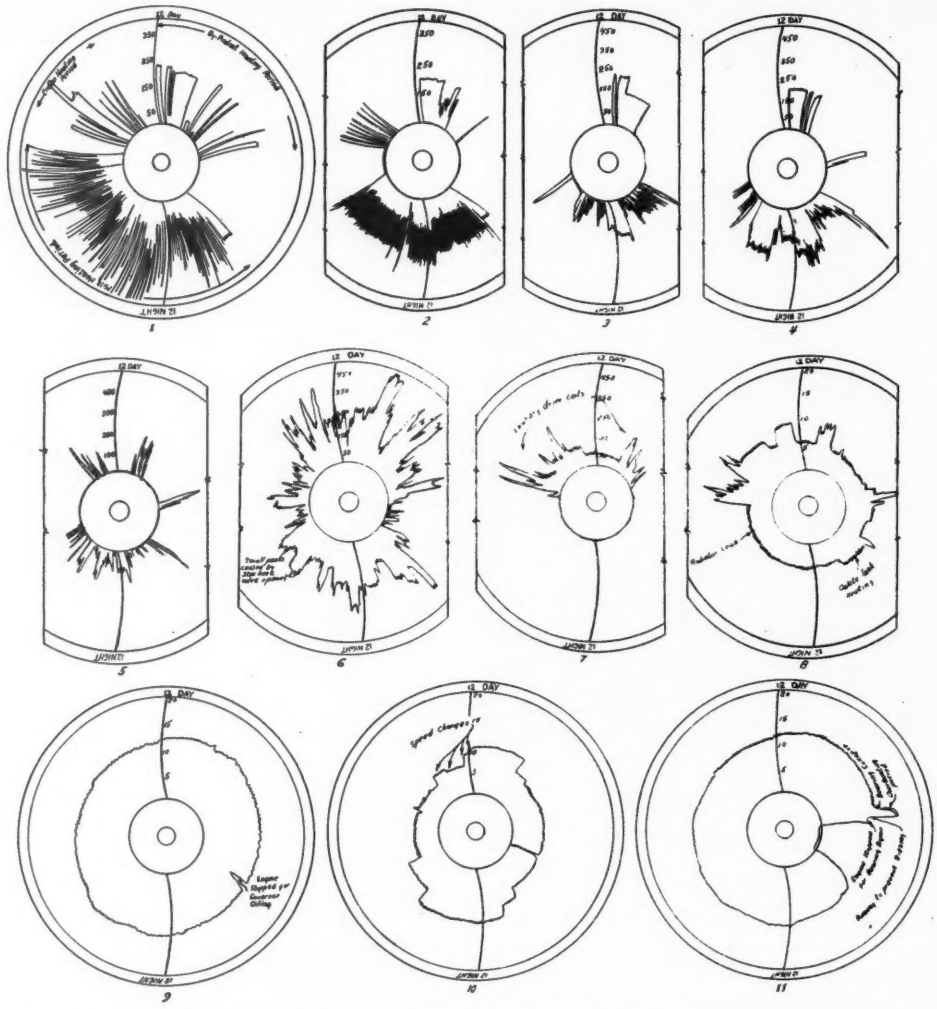


Fig. 4. Eleven charts reproduced to show operating conditions as reflected by recording instruments

preference to the electric machines as long as exhaust steam can be utilized. With exhaust steam wasted to atmosphere, the motor driven machines are slightly less costly to operate.

Available exhaust steam was greater than the above mentioned services needed, so the excess was utilized for heating the return water from the milk plant heat exchangers with a result as shown in Chart 3 where the same load conditions hold true as on Charts 1 and 2. Chart 3 shows a total consumption of 8750 lb. per day. This great saving in live steam was accomplished by installing exhaust head heaters of the Ross type at the hot water tanks and discharging the return water from the milk plant into the tanks through these heaters to condense the exhaust steam. This type of heater is a closed, heavy sheet iron, inverted cone-shaped device in which the exhaust steam in venting to atmosphere must first go through a film of water formed by the slotted ring in the neck of the heater.

The total amount of steam in pounds used in the period covered by Chart 3 is somewhat greater than for live steam alone due to the lessened heat content of the low pressure steam (about 15 per cent of the heat is converted into work in the engines). The live steam, used to give the final temperature regulation, is automatically regulated but the exhaust steam flow to the heater is manually controlled. This is not difficult as the load is a steady one. In Charts 1, 2 and 3 the actual elapsed time of the operating periods vary from each other, but the charts were selected from days when the amount of commodity handled for each of the three periods was substantially the same. The difference in period length is due to the milk plant and rates of handling.

The value of charts for a regular check on operation is shown in Charts 4 and 5 from our files that were taken 1 yr. later than Chart 3. Chart 4 was a check on heater performance during a light period and all live steam was used for heating, the steam consumption was 14,400 lb. and Chart 5 shows the following days operation under the same milk plant load condition as Chart 4 but with the exhaust heating system in operation. The live steam consumption on this day was 5150 lb. By the use of this system all the exhaust steam available from the engine is consumed and in cold days some live steam admitted through an automatic reducing valve must be supplied to the low pressure main to meet the demand.

Chart 6 is from a flow meter that measures the quantity of steam used for sterilizing and steam wash up hose. This service consumes about 40 per cent of the boiler output. Without a check such as this chart provides, the amount used would be virtually impossible to calculate and assumptions made in other plants have been over 100 per cent too large. in one case the actual consumption was 10 times that assumed. By checking the trend of the curve, unusual or careless operating by the wash-up crew can be readily ascertained as the opening of a ¾ in. valve on a steam hose will make its mark on the chart. The many small peaks are due to hose valves opening.

Chart 7 shows steam consumption in the summer time in the maintenance shops and Chart 8 shows the same service in the winter months. The maintenance shops are separate departments embracing a laundry, a paint shop, an auto repair shop and a blacksmithing and body building shop. Due to their distance from the heating main, the shop radiators and heating coils and tanks are operated on live steam. Laundry steam is for the driers and other services. The steam difference of 10,040 lb. between the summer and winter charts is due entirely to the building heating load in the paint shop and auto repair shop. The amount in Chart 7 is that used for drier steam in the laundry for the solution tank in the auto shop and the yard cleaning tanks. The amount used by each service is periodically checked by closing off all services but the one to be measured for the test period. It is only by means of such data that exact charges for steam can be levied against these important departments.

Charts 9 and 10 show steam consumption to one of the engines at different seasons. It is interesting to note that the steam consumption of the engines compare very favorably with the amount calculated from indicator diagrams, making suitable allowances for condensation losses. Chart 9 shows the engine running steadily during the 24 hr. period, excepting a short stop for governor oiling. This was during the summer months when large amounts of refrigeration are needed. The consumption shows an average of about 1200 lb. per hr. for the period with only slight speed variations. Chart 10 shows the same engine during winter operation when refrigerating needs are less. The chart clearly shows every time the governor was moved to change the engine speed. The engine speed is controlled by the load conditions.

Chart 11 is of interest as it shows graphically the results when a partial collapse of a main journal took place and overheated both journal and shaft. As the bearing tightened on the shaft, the load increased on the engine, and the steam demand went to the point shown. Slowing down of the engine, running at low speed to prevent seizing and the final shut down for repair can be clearly followed.

The instruments that furnished the charts shown, together with the many measuring devices on electric current consumption, water flow, etc., have supplied the engineering department with valuable data. These findings, that embrace all branches of the services rendered by dairy power plants, are used in governing the selections of sizes, types and capacities of equipment in the many plants in the California area under the supervision of the Bordens Dairy Delivery Co.'s chief engineer, Mr. J. B. Stapleton, who designed and supervised the layout. By comparing the unit costs in the small plants by means of the monthly bills, to the unit costs set up by actual measurement in this large plant a close check is had on performance in all of the plants.

Low Rates for California Consumers

THE CALIFORNIA State Railroad Commission on March 4 approved the schedule for reduced power rates filed by the San Joaquin Light & Power Corporation and the Midland Counties Public Service Corporation, subsidiaries of the Pacific Gas & Electric Company. The new sliding scale will enable domestic lighting consumers residing in incorporated cities served by the company to enjoy substantially lower rates in direct proportion to their consumption, it was stated.

Effective from March 1 the rate schedule provides that all urban domestic lighting consumers may receive service on the present low combination rate applying to domestic lighting, heating and cooking.

This means that present lighting customers may earn a rate as low at 1.5 cents per kw-hr. for domestic use, according to the announcement of Mr. A. Emory Wishon, president of the two companies.

The companies plan to extend for a year the "inducement" rate now in effect in all rural areas. In addition all domestic consumers will continue to receive benefits of the "half-off" rate for extra use which has been in effect since last December, Wishon announced.

The new domestic lighting rate compares with the old rate as follows:

	New rate cents per kw-hr.	Old rate cents per kw-hr.
First 30 kw-hr.....	4.5	4.5
Next 140 kw-hr.....	3.5	4.5
Next 30 kw-hr.....	1.5	4.5
All over 200 kw-hr.....	1.5	4.0

This reduction follows the series of temporary special rate offers put into effect by the San Joaquin and Midland companies last year which were designed to encourage increased consumption of electricity with the hope that permanent benefits might later be granted.

In announcing the application President Wishon said:

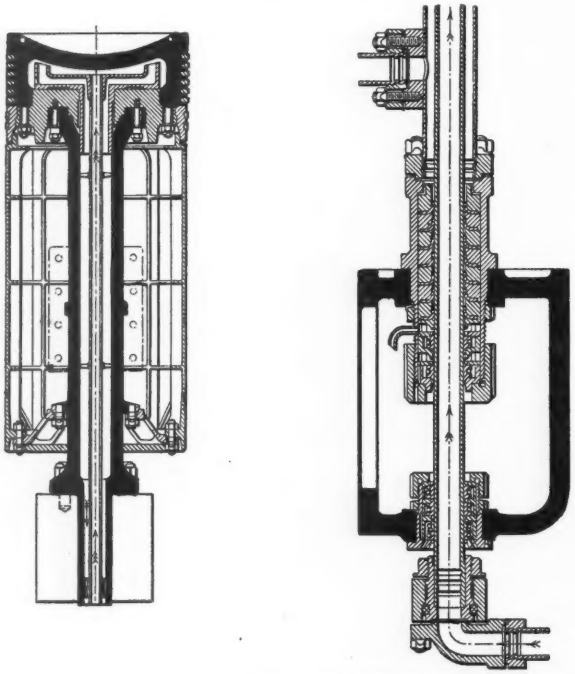
"When we undertook to lower the cost to our consumers by experimental reductions last year we stated our purpose was to increase permanent use. Just as greater production per acre of land reduced unit cost and greater quantity sales in merchandise makes lower prices possible, we felt that additional use of electricity would make possible permanent reduced rates. The response of our customers was such that we are now able to effect the permanent reduction covered by today's application."

Diesels have Quick Load Response

Two 5000-Kw. Units Act as Standby for Hydraulic Turbines and Pick Up Load in 60 Sec.

BECAUSE of their instant availability, Diesel engines make ideal standby equipment for hydroelectric plants. An interesting arrangement of this type, using Tosi engines, was recently made in Rome where a large part of the power is supplied by hydro plants on the Velino and Nera rivers about 50 mi. north of the city. This new Diesel station, called the Montemartini replaces older steam standby equipment for the system, one of the conditions of the contract being that the new units pick up the load within 60 sec. of the demand.

Two generating units are installed, the engines are of the 10 cylinder, 770 mm. by 1120 mm. (about 19.55 by 28.45 in.), single acting, two stroke type, direct



Section through water cooled piston and stuffing box on telescopic joint

connected to 0.8 p. f., 3 phase, 45 cycle, 8800 v., generators with a normal speed of 150 r.p.m. These generators are rated at 5000 kw. but are capable of carrying a load of 5760 kw. for a period of 15 min. Alternators are of the open type, the rotors designed to act as flywheels for the engines.

Special means of assuring effective circulation to the jackets has been made. The liners are formed with an inner and outer sleeve, the inner sleeve being held at the top in the usual way and extending full length of the cylinder with an expansion joint at the bottom. The outer sleeve extends a short distance above and below the exhaust and inlet ports, with a joint on each side. This sleeve is relieved throughout its circumference by vertical slots. The two sleeves are joined by a series of webs, the water circulating through the spaces with a spiral motion. The webs not only direct the water to give effective cooling, but add considerably to the cooling surface. Webs between the discharge and scavenging ports have received particular attention, and the water circulates through these passages at high velocities to give effective cooling and prevent the formation of deposits.

Cylinder heads are formed in two parts, the lower portion in contact with the hot gases being free to expand independently of the upper portion which carries the valve. As in the case of the jackets, a web is cast in the water space in the lower half of the cover to give a spiral water path with high velocities. Each piston is made in four parts, the body proper bolted to the piston rod, a head in contact with the gases, a guide ring around the body and a ribbed skirt bolted to the rod by means of a spacing ring. The body of the piston is forged steel and remaining parts cast iron.

Water is employed for cooling the piston heads and is delivered through a telescopic pipe attached to the A frame. The lower end of this pipe is mounted on a bracket bolted to the crosshead block, and water is delivered to the piston head through a pipe attached to a bracket and up the center of the hollow piston rod.

After passing across the crown of the piston, water enters an annular passage around the circumference of the cooled area, flows down through the outside passage of the rod and leaves the engine by a duplicate telescopic system. A section through the piston and through the telescopic pipe showing the arrangement of the glands is shown by the drawings.

Scavenging air enters the cylinders through two ranges of ports, the upper range being equipped with automatic valves. Air is supplied by a vertical reciprocating pump mounted on the front of the engine, the displacement of the air pumps being 1.6 times that of the main cylinder.

ALTHOUGH discovered nearly three quarters of a century ago, the element Thallium has only recently become commercial. It is used as a rodent poison, in photoelectric cells, as an anti-knock, in tungsten lamps. New uses are ahead.—The Chemical Digest.

Ignition Timing

A sidelight of everyday operation showing why an engineer must know something of equipment details as well as theory

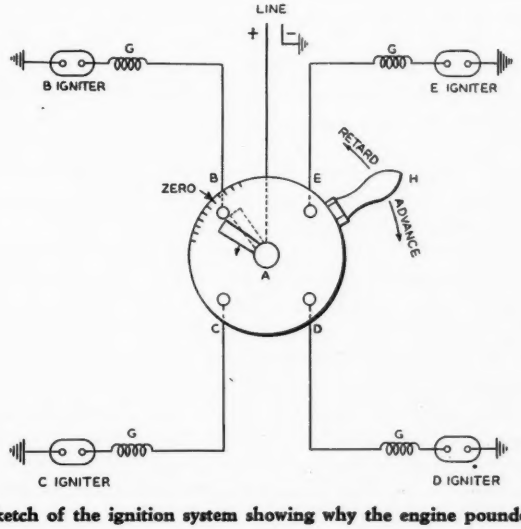
By
EARLE PAGETT

SOME TIME AGO a tandem, double acting, four cycle engine, gave indications that something was amiss by heavy premature ignition when the engine was under heavy load. After some preliminary investigations the ignition system came under suspicion, so the timing mechanism was set at the point where the engine was supposed to fire on dead center and the flywheel jacked over.

Instead of waiting for center, however, the igniter tripped when the flywheel was 40 deg. ahead of center, and this definitely linked the trouble to the ignition system. With the timing mechanism advanced to the point at which it usually ran, ignition would occur around 70 deg. ahead of dead center, so early as to cause the heavy pound.

When asked why he had set the ignition so early, the engineer insisted that it was right, and to prove it, he pulled the timer handle well down, switched on the ignition and then pulled the handle up slowly. Sure enough, the igniter tripped when the pointer indicated zero, or dead center, on the graduations. The engineer was fooled because he was using the breaking edge of the contacts, instead of the making edge to time to.

This will readily be seen, by referring to the sketch which is a schematic diagram of the magnetic make and break system. The "hot" contact A, is revolved by a gear, meshing with a like gear on the lay shaft and is insulated from contact with the driving mechanism or any part of the engine frame. The individual contacts for the igniters, B, C, D, and E, likewise insulated, are stationary in the case, but the case is adjustable through an arc of possibly 40 deg., and can be locked in any position within this arc. The contact between the hot and the stationary contacts, is made earlier by revolving the timer case against the rotation of the revolving contact, and later by revolving the timer case with rotation of the revolving contact, by the handle H.



Sketch of the ignition system showing why the engine pounded

With the flywheel on dead center and the handle raised until the timer is at zero on the graduated scale, it will be noted that contacts A and B are just making but in actual operation, the contacts are just separating on breaking and the actual ignition will have occurred the width of the contacts earlier. When we take into consideration that one degree of travel of the revolving contact is equal to two degrees of flywheel travel, it can easily be seen or realized how serious is a small error at this point.

To correct the error, it was only necessary to slip the gears out of mesh, back the revolving contact up about a sixth of a turn and then turn it in the direction of its rotation until it just contacted with B, as shown by the dotted position of the rotating contact, and slip the gears back into mesh in this position, assuming of course, that the flywheel is on the compression dead center for cylinder B.

This cured the heavy thump and the unit operated up to full load, normally smooth and quiet.

One Man Ice Plant

Carlisle Hygienic Ice Co., Newport, Pa., uses group lift and automatic control. Plant shows an overall power consumption of 50 kw. per ton.

By
M. W. GARLAND

Chief Engineer
The Frick Co.
Waynesboro, Pa.

ONE-MAN ICE PLANTS are not new as many plants intended for one-man operation have been built at different times in various parts of the country. This plant was, however, designed with a specific knowledge of the failures of past designs to fully meet the practical daily requirements of one-man operation.

In this instance the plant is also a one-shift plant: that is, one man works during the day time, and no more, there being no operators or other attendants at the plant during the night. The doors are locked and the equipment operates itself until the following day.

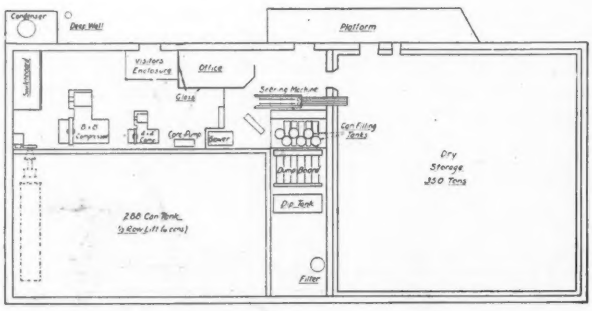
The layout is shown herewith. The office floor, sales platform, dump platform and storage room floor are on the same level. After stepping from the office door all of the essential working parts of the plant are within a radius of 25 ft. Whether inside of the glass enclosed office or just outside of its door, the operator has a clear view of all the equipment, with the single exception of the condenser, which is located outside of the building.

Glancing to the right from the office door, the operator views all of the moving machinery as well as the gage board; to the left is the dump, scoring machine, and storage room entry. It is to be noted that the large gages on the panel board are 10 in. gages usually installed only in large plants, but their utility in being visible from all parts of the plant make them an asset on the one-man job where they are installed so as to be visible from any part of the tank as well as from the office.

When the operator is at any point on the tank, he has a clear view into his office and through the door to the delivery platform. Within 15 ft., after stepping off of the tank, he is on the sales platform.

In designing this one-man plant it was considered essential to have a large ice storage. This storage, with a small tiering machine, will hold approximately 350 t. of ice. The reasons for making the storage of this large size will be given later.

Equipment consists primarily of a 288-can tank having a third-row grid lift of 6 cans; an 8 by 8 in. compressor to carry the summer load; a 4 by 4 in. compressor to carry the winter storage load; a vertical shell-and-tube condenser, and a deep-well pump; dip tank, dump board, can filling equipment, and ice scoring machine. The F-P low pressure air system, with centrifugal blower, is installed.



Layout showing convenient arrangement of the one-man plant

Operation of the entire freezing system, as well as the storage room, is entirely automatic. When the brine reaches a predetermined temperature the agitator motor is started by a thermostat. After a predetermined delay the water pump is started and again after another definite delay the compressor is started. A Frick electric control valve opens a bypass and completely unloads the compressor while starting, and a two-step resistance starter keeps the inrush of current to the motor at a minimum. Here again the necessary automatic delays are provided so that the inrush is all kept within a minimum value: observations of the demand meter chart never reveal a starting period as making a greater load than any of the operating periods.

The compressor is fully protected against high head pressure, water failure, low ammonia back pressure, or agitator failure. The water failure switch is temporarily by-passed during the starting period, which bypass is broken immediately after the large compressor is up to speed. Any failure of the water pump motor to start will immediately cause the equipment to shut down.

No ammonia receiver is provided; the ammonia is trapped from the condenser into the brine cooler. The liquid connection to the storage room is taken off at a low point in the line leading to the float expansion valve. A suitable oil trap is inserted at this low point so that any oil can be drained off, without its being carried over into the storage coils.

The large compressor is started from freezing tank temperatures only. The lowering of the storage room temperature is limited by the Frick electric control system, which has a thermostat cutting off the ammonia feed, and a thermal control regulating the same electric valves so as to give proper adjustment of the feed. This combination of float expansion on the brine cooler with thermal electric valve control in the storage room gives such perfect regulation that at no time, either during starting or running, does any frost appear on the compressor cylinders.

It is the intention of the owners to operate the ice tank in this plant only six months of the year. During the remaining six months the main part of the plant will be shut down and ice will be sold from the storage.

During the summer operating season the small compressor is not used. During the six-month winter shut-down period the 8 by 8 in. compressor is not used and the 4 by 4 in. compressor works automatically on the storage room only. The storage room was made extra large for the purpose of holding sufficient ice to carry through this six-month period. The average power demand charge, amounting to approximately $160 each month, is therefore eliminated during this six month period.

Features of lifting six cans at a time and scoring the ice when passing it into the storage room have much to do with the practical ability of one man to handle this plant. It must be remembered that any single pull of ice delivered to the dump and passed into the storage room requires from 10 to 15 min. time, whether that pull consists of one can or a dozen cans. The grid lift of six cans, while creating a higher initial investment, enables the operator to do all of his pulling within a period of not over 5 hr. Furthermore the operator is permitted to make his pull at any time convenient to him, whether it be in the morning or the afternoon or divided evenly throughout the day. The fact that he pulls all of the ice in a very few hours is in one way contrary to good practice but by addition of a few cans the only serious effect (that of increasing the freezing time) is overcome. In addition there is actually some benefit derived from the fact that they get a period of high ammonia suction pressure at the time of the ice pulling and for a time thereafter, which condition helps offset an increase in horsepower.

Actual data obtained during operation shows an overall power consumption of 50 kw. per ton of ice, the load factor being about two-thirds of full capacity. This definitely proves that the rather irregular pulling is not of serious consequence as long as ample can surface has been provided. The additional investment for can grids, three-motor crane, and complete automatic devices, which in this plant represents an increase in carrying charges of approximately $600 per year, is readily offset by the reduction in labor requirements.

A. C. Control for

Instantaneous Reclosing Circuit Breakers

By
R. L. de Loach
Westinghouse Elec. & Mfg. Co.

THROUGH THE USE of alternating-current control for closing and tripping, the advantages of instantaneous initial reclosing has been extended to small unattended substations where only one or two circuit breakers are located. Unless a number of automatic reclosing circuit breakers are grouped at one point, alternating-current control is less expensive than battery control and the maintenance problem is greatly simplified. Many operating companies and power systems have manually operated feeder circuit breakers on their lines that were installed with liberal interrupting capacity ratings and many of these existing circuit breakers can now be profitably converted to instantaneous initial reclosing service. Alternating-current control for this exacting class of service has given a good account of itself in numerous installations during the past two years.

In any scheme of automatic reclosing it should not be possible for the circuit breaker to receive more than one closing impulse for each predetermined reclosure, otherwise repeated reclosures may take place and the circuit breaker be badly damaged or destroyed. With the usual time delay initial reclosing, pumping is comparatively easy to guard against, but it becomes an important problem with instantaneous initial reclosing and especially so when alternating-current control is used. With this control, the supply is an uncertain quantity. Should the circuit breaker be closed against a nearby fault, the control voltage may collapse, almost to zero, during the closing cycle, depending upon the distance of the fault from the substation, the line characteristics and other factors. The reclosing relay must, therefore, be so arranged that pumping cannot take place regardless of how low the control voltage drops during the instant the circuit breaker is closing.

Another important requirement of alternating-current control is that the reclosing relay should not depend upon an energized coil to hold it in the locked out position. Obviously, with such a relay, even a momentary loss of control voltage would cause it to re-cycle and probably damage the circuit breaker by uselessly closing it several times against a permanently faulted line.

For operating the circuit breaker, solenoid mechanisms of the mechanically trip free type have been found most satisfactory. Motor operated centrifugal type mechanisms have been used but have not been generally adopted due to their greater mechanical complication and maintenance requirements.

Energy for closing the circuit breaker is supplied to the solenoid in the form of direct current by a small copper oxide rectifier. This rectifier is an economically practical device for closing circuit breakers from alternating-current by virtue of the intermittent nature of circuit breaker closing service and the fact that a rectifier of this type is capable of supplying enormous outputs for short periods of time without damage. For circuit breaker operation the rectifier is momentarily supplying outputs of the order of 8000 per cent of its normal continuous ratings. Since the alternating-current control power is removed from the rectifier by the circuit breaker "cut-off" relay generally within less than 15 cycles, the high thermal capacity of the unit prevents damage during this short period of time.

Most circuit breakers operated by trip free mechanisms require a slight time delay after a trip-out before the trip-free mechanism recouples with the breaker

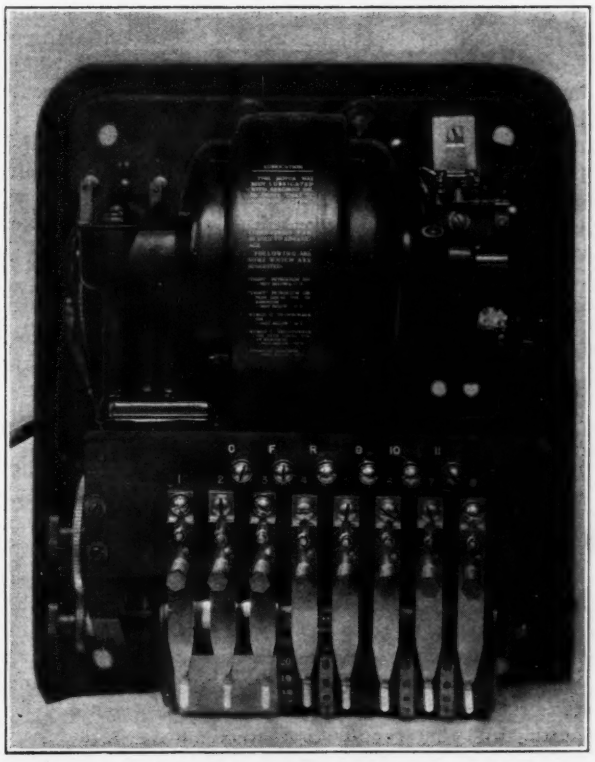


Fig. 1. Periodic reclosing type relay for a.c. control with instantaneous feature

proper. For this type of circuit breaker, it is sometimes necessary to insert a time delay of from 5 to 15 cycles before the instantaneous reclosure; otherwise the reclosing relay would attempt to close the circuit breaker before the trip-free mechanism had retrieved. This would result in the functioning of the solenoid mechanism without a corresponding operation of the circuit breaker. Since the auxiliary switch controlling the reclosing relay is actuated by the circuit breaker, this switch would not function to re-set

the relay. The final result would be the locking out of the reclosing relay, rendering the circuit breaker inoperative.

Over-current protection is by three induction type relays having circuit opening contacts. Where dependable timing is required, induction type relays are necessary but these have only recently become available with circuit opening contacts for alternating-current tripping. Formerly, when standard induction type circuit closing relays were used, it was necessary to employ some auxiliary device such as a tripping reactor. This generally over-burdened the current transformers, especially if they were of the bushing type. With induction type, circuit opening relays, under normal conditions the only burden on the current transformers consists of the relays and the leads. This permits of dependable timing, even with bushing type current transformers, provided that the low energy over-current relay is used and the circuit breaker is equipped with the sensitive spring tripping attachment. This attachment provides space for four trip coils and the actual tripping is by means of a spring which is compressed during the circuit breaker closing stroke. The trip coils release this spring through a light toggle mechanism. The volt-ampere burden at the tripping point is sufficiently low so that dependable tripping can generally be had from most bushing type current transformers as low as 20 to 1 ratio. One of the trip coils can be wound for potential and used for hand tripping from a control switch or for automatic tripping by a standard circuit closing ground relay, obtaining tripping potential from the station service transformer.

The protective relays are provided with quick resetting contacts. This feature is essential for instantaneous reclosing service; otherwise there is danger of the breaker being reclosed before the protective relay contacts have had time to back off. Over-current relays protecting feeder circuits where the load is composed largely of motors, must be set fairly high, generally from 400 to 700 per cent of normal line current, depending upon the load characteristics. Unless high settings are used, when the instantaneous reclosure takes place, the inrush current to motors may again operate the protective relays.

Extensive service records by a prominent Southeastern operating company, which has pioneered in the practice of instanteous reclosing, show that more than 75 per cent of all outages can be eliminated, or rather the deleterious effects of interruptions can be nullified so that for most practical purposes they can no longer be classed as outages. Extensive use of the alternating-current control system described has made it possible for this company to improve its service in many sparsely populated outlying districts to a point heretofore never considered economically feasible.

TEMPERATURE of 68 to 70 deg. is best for health, according to the New York Commission on Ventilation. Higher temperatures result in lowering of activity and are expensive to maintain. The extra cost above 70 deg. is estimated as 3.1 for each degree increase, or, for 75 deg. 15.5 per cent and for 80 deg. 31 per cent.

Birds and Beasts Cause Extra Work for Linemen

BY C. W. GEIGER

ELECTRIC CONSUMERS and Pacific Gas and Electric Company linemen in California occasonally have rather a bad time all on account of birds and animals coming in contact with transmission lines, causing short circuits and plunging communities into darkness.

On one occasion a gobbler on a turkey ranch near Melones picked out the 17 kv. transmission wires for a roosting place and caused a short circuit, plunging several Calaveras county communities into darkness. On another occasion an owl made the same mistake south of Sonora and that city and neighboring Tuolumne towns were without lights for a time. To add to the trouble the wires fell on a fence, starting a grass fire that burned over about 100 acres.

When the circuits out of Knights Landing substation tripped on several successive nights and the company men traced the cause of the interference, they found that a number of pelicans had collided with the 11 kv. transmission line where it crossed a canal. Nine victims were found under the high wires against which they met their fate. These birds weighed about 25 lb. each and had an 8-ft. wing spread. So heavy were these clumsy birds that when they hit the line they forced the wires together, causing a short circuit that at one and the same time reduced the pelican population and "cut out" the line at the substation.

Bobcats, tough as they are, can't bite 60,000 v. power wires and get away with it. One tried it near Taft, and immediately his family went into mourning. The bobcat had scaled a power pole to see if he could spot anything in the neighborhood that looked like a meal. Two linemen spotted him and climbed up to remove him before he could cause line trouble. Mr. Bobcat tried to discourage them with snarls and hisses, but the linemen went on up and attacked him with long sticks. He fought a ferocious but losing battle. And finally, just plain mad, he turned and bit the first thing that caught his eye. It was a power wire.

Five hawks got away with this million-to-one chance near Corcoran, California. Since the region is barren of trees, Papa and Mama Hawk built their nest at the top of a 70-ft. transmission line tower. And there, with instant death on all sides, Mama Hawk laid her eggs and hatched out three little ones, while Papa scoured the district for rabbits, ground squirrels and other small animals to feed his family.

Finally the nest was discovered by maintenance men while making an inspection trip and was removed for two reasons—to protect the birds and to eliminate the possibility of short circuits. But the eviction didn't take. When the crew made its next inspection trip 33 days later the hawks were occupying a new nest in exactly the same place. They were ousted again, and this time they seemed to understand that they simply were not wanted, so they moved out of the neighborhood.

Generation of "KILOCYCLE KILOWATTS" *for* Industrial Use

By L. D. MILES
General Electric Co.

FREQUENCIES of from 1000 cycles to 100,000 cycles per second are quite different from those we ordinarily are concerned with in power plant operation, yet such frequencies are used for various purposes in many industries. The problem of generating such "kilocycle kilowatts" is quite often one beset with many economic difficulties, and its solution demands accurate knowledge of the different methods available.

In this article, which is an abstract of a paper published in the March number of "Electrical Engineering" of the A.I.E.E., the author describes a new method of generating such high frequency power. While it is still in the development stage and not yet available it is simple and inexpensive and should do much to further the use of this type of electrical power.

HIGH FREQUENCY alternating currents are used in many manufacturing processes at the present time. The frequencies used are not of the extremely high order used in radio but in the range between 1000 and 100,000 cycles. Thus, in the smelting of scrap metal frequencies of 1000 to 2000 cycles are used. For manufacturing razor blade steel, 4800 cycles is common; 30,000 cycles is used for proximity pipe welding and for the sterilization of milk, 50,000 cycle power is found most effective. In each case, experience discloses that there is an optimum frequency for doing a particular job.

The comparatively high initial cost of equipment for generating these so-called kilocycle frequencies, however, has prevented both the further industrial use of kilocycle frequency power and a greater amount of experimentation to determine the most suitable frequencies for particular purposes. Several methods for obtaining frequencies of this order are available but most of them are expensive and not all are flexible as regards the ability to alter the frequency when necessary. Recently, however, a tube, known as the arc oscillator tube, has been developed which is suggested as a suitable source of high frequency power. These new tubes are still in the development stage and not yet commercially available, but the method holds forth considerable promise of commercial success. The cost of generating high frequency power with this new tube is lower than with the usual type of equipment.

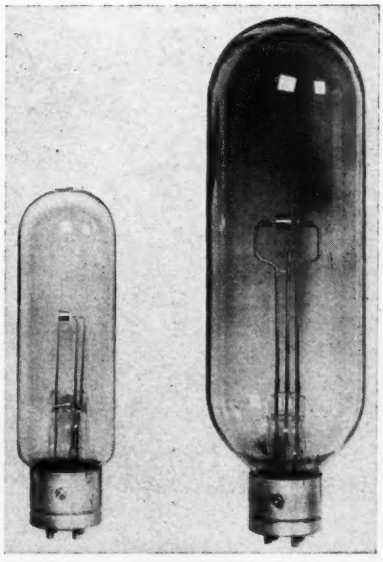


Fig. 1. Two typical arc tube oscillator tubes. (left) 50 watts and (right) 500 watts output.

Characteristics of Power Sources

In general, there are three types of apparatus in common use for securing kilocyle frequency power; first, rotating equipment; second, high vacuum tubes and associated equipment, and third, gaseous tubes and associated equipment.

In classifying the merits of these systems we find that rotating equipment is expensive. Its operating costs are reasonable low, its efficiency fair, its life good. It can be built for industrial supply voltages but it requires a good foundation and is rather heavy.

High vacuum tube equipment also is expensive. Its operating costs are low; its frequency fair and its life fair. A rectifier must be built into the unit as high direct voltages are usually required. Complete equipment is rather bulky but the weight is light.

Gaseous tube equipment has moderate initial and operating costs for installations at 1500 cycles per second or less. Above 1500 cycles costs mount with fre-

quency. Efficiency is good and life is fair. Industrial direct voltages may be used on the newer tubes. Space requirements and weight are moderate.

In any of these systems operating costs, efficiency and life are reasonable, but the principal curtailment to general use is high initial cost. Now, however, a fourth source of high frequency power becomes available in the arc tube and this makes possible a source of kilocycle frequency power at a low initial cost. In addition to low initial cost, it is characterized by low operating costs, fair efficiency, fair life, operation on industrial direct voltages, simplicity and small weight requirements.

The arc tube consists essentially of two electrodes closely spaced in inert gas under high pressure. Figure 1 shows two typical tubes rated at 50 and 500 watts output, respectively. The tube is used in a circuit con-

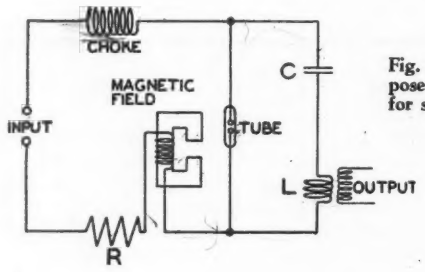


Fig. 2. A general purpose arc tube circuit for supplying kilocycle power

sisting of a choke coil, stabilizing resistor, a capacitor and an inductor connected as shown in the accompanying diagram. Those who are familiar with the old high frequency arc generator will recognize in this circuit many points of similarity with that system, in fact, the principle is essentially the same. The arc tube, however, has three outstanding points of superiority over the open arc; (1) an optimum gas pressure may be used to give maximum power; (2) the electrodes may be spaced permanently for maximum efficiency at rated output; and (3) oxygen and water vapor may be driven from the tube before the inert gas is admitted, thus insuring uniform power, better efficiency and longer life.

When voltage is applied at the input terminals to the circuit, capacitor C is charged through resistor R. The choke causes a momentary pause in the starting cycle but not thereafter as it maintains a steady continuous current during operation. The tube conducts no current until the capacitor C is charged to sufficient voltage for breakdown between tube electrodes. At this point the tube ionizes, acts as an instantaneous short circuit and allows C to discharge through the LC tube circuit. Line current inrush is prevented by the choke. The choke has the function of maintaining a continuous current input while high frequency oscillation takes place in the branch of the circuit known as the LC tube circuit. At the instant C is completely discharged, a high current is flowing in the LC tube circuit. At this instant the energy of the circuit is entirely electromagnetic and is stored in the magnetic field surrounding the inductor L. The collapse of this magnetic field induces an e.m.f in circuit which continues the current flow and the capacitor charges in the opposite direction. This drives the

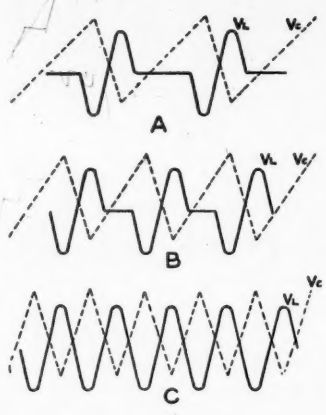


Fig. 3. Wave shape of output of circuit shown in Fig. 2.

V_c—Voltages across capacitor C

V_L—Voltage across conductor L

A—Output for slow charging rate of capacitor C

B—Output for faster charging rate

C—Sine wave output for optimum charging rate

tube voltage negative, whereupon the arc extinguishes and the tube is again an open circuit. After this the capacitor C again becomes charged through the resistor R and the cycle is repeated.

The frequency and character of oscillation is, of course, a function of the values of inductance and capacity in the circuit. The frequency of the pulses is governed by the capacitor charging rate. The effect of successively decreasing the capacitor charging rate is shown in Fig. 3. Part of C of Fig. 3 shows that if the charging periods are made short enough, sinusoidal pulses of voltage appear in uninterrupted sequences, giving sine wave output.

Variable frequency is accomplished by changing either the period of charge or the periods of both charge and discharge of the capacitor.

The arc tube is destined to supply cheaper power for industrial utilization because: First, it is adaptable to varying needs—frequency can be changed conveniently; second, equipment can be made economically in any reasonable size, either to supply only a few watts or to furnish 50 or more kilowatts; third, arc tube equipment operates directly from industrial direct voltages; fourth, there are no moving parts to wear, and operating costs and maintenance are low; fifth, little associated apparatus is required; sixth, tube construction is not complicated, and hence with reasonable production, cost should be low.

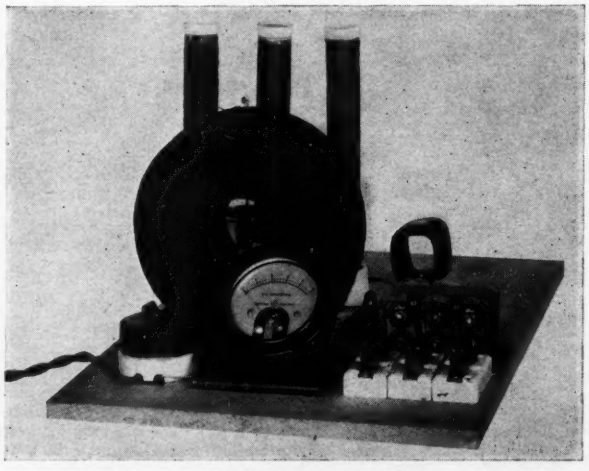
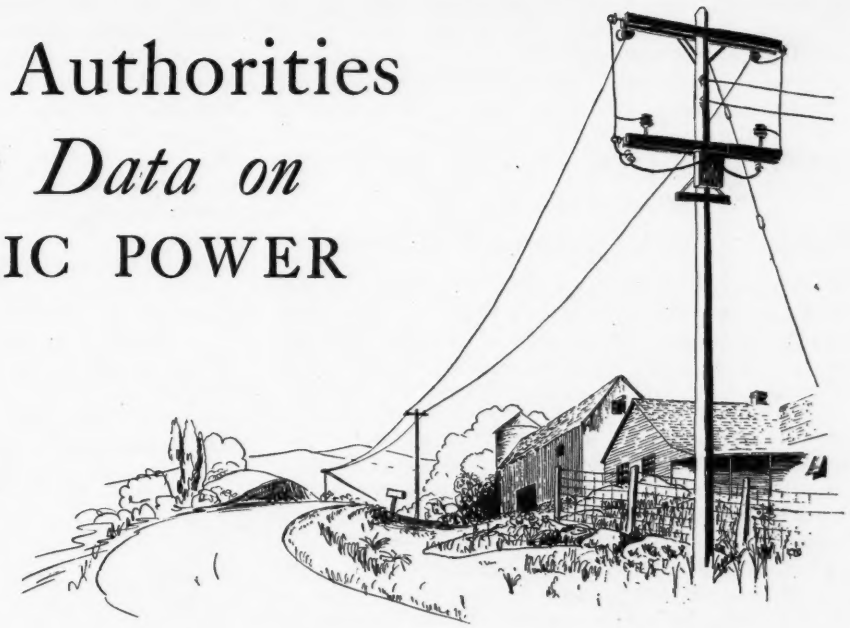


Fig. 4. A 50 watt arc tube oscillator

National Authorities *Present Data on* ELECTRIC POWER

Federal Power Commission, Edison Electric Institute and War Department Engineer Contribute Data and Opinions Bearing on Subject of Interconnection of Electric Power Systems



EXTREMELY important to those whose occupation deals in any way with the generation or use of electric power is the Interim Report of the National Power Survey made public on March 31 by the Federal Power Commission. This survey was authorized by the President in August 1933 who directed the Commission to "make a survey of the water resources of the United States as they relate to conservation, development, control, and utilization of water power; of the relation of water power to other industries and to interstate and foreign commerce; and of the transmission of electrical energy in the United States and its distribution to consumers" and on the basis of this survey to formulate a program of public works.

In the following paragraphs, abstracted from the letter of transmittal are statements and data that will warrant consideration when determining policies to be carried out by the government and utility companies.

"This is a preliminary report on the results of the first engineering study of the electric light and power industry that has ever been made on a national scale in the United States.

"Other nations have made elaborate surveys of their power resources and requirements extending over a period of years and involving large expenditures. Regional surveys have been made in this country and have proved their value both to the government and to industry. Individual utility systems have made detailed studies of their available resources and probable demands for power at an expense exceeding the appropriation made for this nation-wide survey. But hitherto no attempt has been made in this country, either by the government or by any private agency, to determine from a national standpoint the relation between present and future requirements for electrical energy and the necessary capacity to meet such demand. Nor has there been an appraisal of the efficiency of the generating plants of the major public and private utility systems.

Estimates Demand Upon Resumption of Normal Industry

"This Interim Report presents a birdseye view of certain major aspects of the electric light and power industry. It is not a microscopically accurate picture such as might be obtained if it were possible to make a thorough study of the conditions in each separate district. The possible margins of error are, however, small and the results are not likely to be materially affected by the refinements which will be employed in the preparation of subsequent reports. It is significant that the results reached by the National Power Survey in estimating the demand that will exist upon the resumption of normal industrial activity coincide almost exactly with the forecasts for the same districts prepared by private companies and municipal plants for their own purposes.

"This information is of great public value not only in its bearing upon conditions in the electric light and power industry but also in relation to the problems of unemployment and industrial recovery. Much has been said during the past five years about the supposed surplus of electric generating capacity in the United States. Until quite recently this has been true enough if the situation was viewed from the short-range standpoint of the relation between existing capacity and the immediate demand during a period of depression. In recent months, however, the use of power has been rapidly increasing until in many districts the demand is nearing the limit of available efficient generating capacity.

"It takes 2 yr. to plan and construct a large modern steam plant and from 2 to 7 yr. to plan and build a large water power project. It is the part of wisdom, therefore, to determine at this time what new generating plants and transmission lines will be required to meet the demands that will be created by resumption of normal industrial activity and where they should

be located to supply the demand most efficiently and economically. It is time also to take stock of the existing private and public plants and ascertain which of them are inefficient or have become obsolete. Finally the national interest requires the most accurate possible inventory of the Nation's undeveloped water power resources in their relation to present and fuure markets for power.

SUMMARIZES RESULTS PRESENTED IN INTERIM REPORT

"These are the principal lines of inquiry that have been pursued by the National Power Survey during its initial stages. The first tentative but significant results are presented in this Interim Report. They may be summarized as follows:

"1. The use of electricity for domestic purposes as well as in certain branches of industry has grown at such a rate during the depression that, upon a resumption of normal industrial activity, the demand for power will be at least 4,000,000 kw. in excess of that which existed in 1929. This is equivalent to the capacity of some 50 large generating stations.

"2. Very little new generating capacity has been constructed by the privately owned utilities since 1930. As a result the capacity of existing plants is 2,325,000 kw. less than the demand that will exist for power upon a resumption of predepression industrial activity, assuming maintenance of normal reserve capacity.

"3. This shortage is being rapidly accentuated by the obsolescence of plants which would have been replaced under normal conditions. As of January 1, 1935, 56 per cent of the total installed steam-electric capacity of the United States was at least 10 yr. old, 11 per cent was 20 yr. old or older, and about 1 per cent at least 30 yr. old. Inefficient and obsolete plants with a capacity of at least 2,000,000 kw. should be scrapped and replaced within the near future.

"4. Analysis by districts of the relation between the capacity of existing plants and the demand that will be created with the resumption of normal industrial activity shows that critical shortages will exist in almost every section of the United States. The only regions in which substantial surpluses of capacity now exist to meet normal demand are Florida, parts of Michigan and Illinois, an area along the lower Mississippi, parts of Texas, and North Dakota, Idaho Utah, New Mexico, Montana, Washington, Minnesota, and Oregon.

"5. Government plants provided for or under construction will meet these shortages in certain limited areas. Only one major power development and one major municipal plant are now under construction. Many of the regions where the greatest power markets now exist and where the shortage will be most acute when industrial activity is renewed do not have projects under construction at the present time sufficient to carry the loads that will develop upon resumption of normal industrial activity.

"6. In view of the time required to plan and construct large generating plants, whether hydro or steam, early construction of new plants with an aggregate capacity of between 3,000,000 and 4,000,000 kw. is imperative. This would involve capital expenditures of at least $300,000,000.

"7. The critical shortage of existing generating capacity most seriously affects the great industrial districts of the East and Middle West. It would, therefore, be disastrous in case the United States should become involved in war. The situation might be even more acute than that which existed during the World War when, in many districts, electric service had to be denied to domestic and commercial customers and non-essential industries to meet war needs for power.

"8. Careful planning, under federal supervision, of new power plants and facilities for transmission is required to promote the safety and welfare of the Nation. Selection of sites for hydro or steam plants, to be developed either by public or private agencies, should take into consideration not only the pertinent engineering and economic factors but also essential considerations of broad national policy."

MAJOR FACTORS DISCUSSED IN INTERIM REPORT

1. Development of Electric Power in the United States.
2. Power Requirements upon Resumption of Predepression Industrial Activity.
3. Adequacy of Present Power Producing Facilities.
4. Surplus and Deficit of Dependable Capacity.
5. Power Plants recently completed and under construction.
6. Undeveloped Water Power.
7. Fuel Resources.
8. Relation of Water and Fuel Power.
9. Interstate Transfers of Power.
10. Special Phases of the Survey.
11. Importance of Power in National Defense.
12. Summary.

Statistics on Interstate Power Compiled by Edison Electric Institute

TO WHAT extent electric power generated in one state is transmitted across the border into another has been a controversial point brought up many times during discussions of regulatory measures proposed in state as well as Federal legislative bodies. The most recent statistics were published in the March issue of the Edison Electric Institute Bulletin together with comments that are enlightening to those interested in formulating their opinions on the details of present day practice among utility companies. The article as published follows:

The following table shows the amount of interstate transfers of electric current during the past 7 yr. and the ratio which this amount bears to the total power generated by the electric light and power industry in the United States:

	Kilowatthours Generated	Interstate Movement	Per Cent
1928—	80,453,498,000	9,314,288,000	11.7
1929—	90,084,428,000	11,134,284,000	12.5
1930—	88,591,736,000	11,901,681,000	13.5
1931—	85,575,307,000	12,488,401,000	14.6
1932—	76,885,248,000	12,595,460,000	16.4
1933—	79,259,087,000	14,146,000,000	17.8
1934—	84,532,153,000	14,800,000,000	17.5

It will be observed from this table that the amount of interstate power has been increasing throughout the period and that with the exception of the last year the ratio also has been increasing; that is, the amount of interstate power has increased faster than total generation. The growth of the percentage of interstate power reflects in part the completion and effectuation of interconnection programs, but to a still greater extent it results from the building and placing in operation of a few very large generating plants located across state boundaries from their markets.

Few Plants Deliver Interstate Power

Two-thirds of the entire interstate business in electric power comes from a very few plants, 25 water power and 8 steam plants. Notable among these are the State Line steam plant of East Chicago, supplying the Chicago market but located just over the line in Indiana; the Conowingo, Maryland, hydroelectric plant, supplying the city of Philadelphia; and the Cahokia steam plant, supplying St. Louis, Missouri, from the Illinois side of the Mississippi. Two of these generating plants, the Conowingo and State Line generating stations, which came into full operation during the period covered by these statistics, contribute almost 20 per cent or one-fifth of all interstate power and have been largely responsible for the increases shown in the table.

The bulk of interstate power flows in one direction and is carried over a comparatively few interstate lines. Power traded back and forth amounts in kilowatthours to about one-sixth of the total interstate transfer of power.

Practically all interstate sales of power are at wholesale rates. Retail transactions amount to a negligible fraction of 1 per cent.

Interstate power transfers taking place between divisions of the same company operating in two or more states account for about half of the total. Almost an equal amount takes place between affiliated companies, and only 6 per cent of the total interstate power business is between non-affiliated companies.

Expressed in terms of total power generated in the United States, 82½ per cent of the total supply in intrastate, 16½ per cent is transmitted over state boundaries but the transaction remains within the same company or is between affiliated companies, and only 1 per cent of the total is transferred between non-affiliated companies across state lines.

The total amount paid for this interstate power between non-affiliated companies amounts to less than $5,000,000 per year, or about one-quarter of 1 per cent of the gross revenue for the entire electric light and power industry.

State or other local regulatory authorities, according to legal opinion based upon decisions of the Supreme Court, have jurisdiction over interstate power transactions within the same company or between affiliated companies. Only those interstate power sales between non-affiliated companies are exclusively within Federal jurisdiction so far as concerns the direct regulation of the wholesale rate. Of course, the rates which may be charged the ultimate consumers, in all cases are subject to control by state or other local authority. Lack of power to control this wholesale rate for interstate power transfers between non-affiliated companies constitutes the so-called gap in local regulation. The width of this gap is indicated by the fact that the amount of money involved is about one-quarter of 1 per cent of the gross revenue of the industry.

War Department Is Surveying Water Power Resources

By Glen E. Edgerton, Lieut. Col., Corps of Engineers

MY FIRST reaction to the article on "Interconnection of Electric Power Systems" in the March issue of Power Plant Engineering, is that your magazine is rendering an important service in inviting an open discussion of this question, the importance of which at the present time can hardly be exaggerated. It is only to be regretted that this discussion cannot be similarly developed in the non-technical press. Usually, the power man, regardless of his affiliations, is well aware of the complex nature of the power interconnection mechanism, with its technical, economic, and social interrelationships. The average citizen, on the other hand, with his proneness to generalization, is likely to fall into the error of over-simplifying a problem entirely too intricate for generalization. The dangers involved are apparent, and they may be aggravated if the whole question of power production and distribution becomes more and more a subject of political rather than technical consideration. Whether this trend is to lead to increased social benefits will depend largely, of course, as pointed out in your article, on how thoroughly the many interdependent relationships, with their supporting data, are developed and analyzed, and the extent and effectiveness with which the essential facts and conclusions are brought to the attention of the appropriate legislative and executive authorities.

As suggested in your article, there is need for a comprehensive factual survey of the entire problem, together with a thorough analysis of the technical and economic features involved. It is understood that various agencies, both public and private, are at present engaged in the collection of data pertinent to the production and distribution of electric energy. The electric power survey now under preparation by the National Resources Board should supply some valuable information.

As you are undoubtedly aware, this Department (War Department, office of the Chief of Engineers) has been engaged since 1928 on a comprehensive survey of the water resources of the country with respect to power, navigation, flood control, and irrigation, in accordance with the provisions of House Document 308, Sixty-ninth Congress, first session. During this time some 200 river systems have been studied and over 2500 potential water power sites investigated. A summary of the principal data and results pertaining to these sites together with a set of maps showing their locations is nearing completion in this office.

It is obvious that the mere assembly of data is only one step in a thorough analysis which would lead to reliable conclusions. Your current article should encourage a more general consideration of all phases of this problem, by both private and governmental agencies.

Calculation of Ice Freezing Time

By CARL WILKIE
Los Angeles, Cal.

In the September 1934 issue page 432, H. A. Cranford discussed the time requirements for freezing ice under different conditions and gave formulas to assist the operator to eliminate guesswork. Mr. Wilkie does not entirely agree with Mr. Cranford regarding the practical application of some of the constants to a well operated plant and goes into greater detail about the calculations that the operator should be able to make to check his performance.

EFFICIENCIES of ice freezing tanks are based on heat transfer so new tanks should be designed, and old tanks redesigned to give the highest practical heat transfer rate. The cost of changing an old tank is small. In any number of ice tanks the cans rest on 2 by 4, or, 3 by 3 in. timbers, with a space under the cans, which allows the brine to short circuit as shown by Fig. 1. It is not necessary to have brine pass under the cans, the bottom end of the cake will always freeze, it is the top end that requires the attention. Fig. 1 shows old style can rest.

Some old tanks also have a space from 4 to 6 in. on one side, the full length of the tank as shown at the right of Fig. 2. Imagine the amount of brine that would flow through this space. To maintain high brine flow between the cans and around the coils, it is necessary to shut off all short circuits as indicated by Fig. 2. After this is done, little energy is required to build up a brine head, as there is little space between cans in a coil tank. This brine head should be approximately 1 in. for every five rows of cans. For example, a tank 30 rows long, would require a brine head of 6 in., in front of the propeller, tapering to 0 in. at the opposite end of the tank and with a propeller on the opposite side and end to build up a 6 in. head necessary for that side.

The tank floor should be solid under the cans and slope from 6 to 0 in. just as the brine flows, as in Fig. 2, especially if the tank contains old standard cans. When long cans are used it is not necessary to give the floor as much pitch, say 3 to 0 in. as the extra long cans help to meet high brine agitation. The cans should be submerged as much as possible, at least 5 in. that is, the brine should be that height above the ice after it has been frozen. This alone will decrease the freezing time from 6 to 7 hr. with a brine temperature of 14 deg. F. Long cans are necessary where deep submersion is desired and means of holding the cans down must be provided. For 14 deg. F. the brine should not be stronger than 64 to 68 solometer reading as it is not so difficult to block the cans down with low strength brine.

Referring to Mr. Cranford's article on page 432 of the September issue, Mr. Cranford presents a formula for calculating the time required to freeze a cake of ice 11 in. thick, with an average brine temperature of 14 deg. F., seven times the thickness of the ice squared, divided by 32, minus the brine temperature. Substituting the formula

$$(7 \times 11 \times 11) \div (32 - 14) = 47 \text{ hr.},$$

as the freezing time, 7 being a constant, 11 the thickness of the ice, 14 the brine temperature and 32 the freezing point of water.

When it is necessary to use 7 as the constant for 14 deg. brine, it does, in my opinion, represent poor ice freezing tank performance. I would never be content operating an ice tank where it required 47 hr. to freeze ice with that temperature brine. With good tank performance the constant should be from 6 to 6.3. For example take a tank designed as described above: Flooded coils, i.e. bottom ammonia feed; cans submerged 5 in.; one in. of agitation for 5 rows of cans; 250 lineal ft., 1¼ in. pipe per ton; 14 deg. F. constant temperature brine; 40 deg. F. water to cans and for core filling.

Harvest the ice as fast as it freezes, so as not to have any more rows frozen ahead of the pull than is absolutely necessary. The second row ahead of the one being pulled should have cups 2 to 3 in. deep. When cans are submerged 5 in. a cup 3 to 4 in. deep is only about ½ in. wide at the top and closes up quickly.

Effect of Submergence

When ice is frozen under the above conditions the constant in the formula becomes 6 instead of 7, or $(6 \times 11 \times 11) \div (32 - 14) = 40$ hours as the freezing time. The following are results obtained from cans being submerged at different depths in 14 deg. F. brine and with a water temperature to the cans of 40 deg. F.

Brine level with ice when frozen to a 2 in. cup, temperature of air above ice and under the cover 27 deg. F., freezing time of ice 46 hr.

Ice submerged 5 in. below brine level with ice frozen to a 2 in. cup, air temperature above ice and under the cover 19 deg. F. freezing time 39.5 hr.

Can filled half full and blocked down, air temperature above the ice and under the cover 16.5 deg. F., freezing time 27 hr.

There is no doubt a limit to the effect of brine agitation and if the agitation is increased from 1 in. to 1½ in. per 5 rows, the tank does not seem to produce any more ice, at least not enough to be noticeable. On the other hand, lowering the agitation to ½ in. per 5 rows will produce a noticeable change in freezing time in a few hours. The effect of submerging, on the other hand seems to know no limit. I put 100 lb. of water in a 400 lb. can at 6:00 P. M. and blocked it down. At 7:00 A. M. the following morning it was frozen solid. Mr. Cranford says the length of the cake of ice makes no difference and only the thickness is important. I appreciate that, but how much the brine is above the ice is also tremendously important.

Can Capacity

Fourteen cans per ton of ice is a lot of can capacity. Of course if they were filled with 70 deg. F. water, 14 would be about correct. With 40 deg. F. water to the cans, a tank should produce a ton of ice for each eleven 300 lb. cans. To get 300 lb. of ice it would be necessary to fill the cans with 306 lb. of water as it will require a few pounds for bathing the ice loose from the cans.

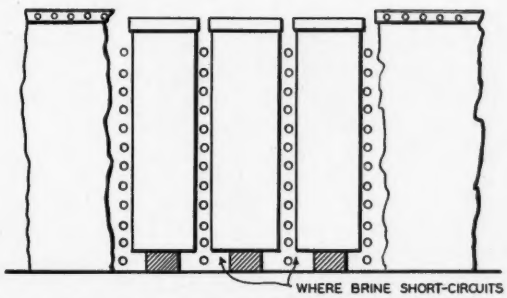


Fig. 1. End view of old style case rest which allows short circuiting of the brine

Cans filled with 306 lb. of 40 deg. F. water would require the extraction of $8 + 144 + 7 \times (306 \times 6.66) = 324{,}035$ B.t.u. or 1.12 t. of refrigeration per ton of ice. If cores are pulled, assuming 23 lb. of 40 deg. F. water per core, the B.t.u. per ton would only be increased by 1225. The following is a summary of ice freezing tank performance.

While the particular plant I have in mind used 400 lb. cans, the figures can of course be converted to 300 lb. cans. The plant was designed and erected by plant engineers, and has been in operation 15 yr., but reputable ice machine companies have, in the past, built plants which rated as high in efficiency and were perhaps less complicated.

An engineer operating an ice plant should be able to make any of the calculations shown in the following summary:

	Duration of tests, days	14
	Time of season, month	July
	Total number of 400 lb. cans	2,700
	Length of cans, inches	64
A	Number of cans per ton of ice	8.65
B	Agitation, inches brine head per 5 rows cans	1.3
C	Ice submerged in inches	6.5
D	Total lineal ft. 1¼ in. standard pipe	78,546
E	Total lineal ft. 1¼ in. pipe per ton of ice	251
F	Total square feet external pipe surface	34,150
G	Total square feet external pipe surface per ton of ice	109.4
H	Total pounds water per can	408
I	Average pound core water per can	30
J	Total tons ice harvested per 24 hr.	312
K	Total tons delivered to day storage per 24 hr.	306
L	Average freezing time, hours	42.35
	Initial temperature of water to cans deg. F.	40
	Initial temperature of water to cores, deg. F.	40
M	Final temperature of ice, deg. F.	18
	Specific heat of ice (taken as)	0.5
N	Total B.t.u. cooling and freezing water	99,254,160
O	Total B.t.u. cooling core water	367,200
P	Total B.t.u. heat loss (due to radiation)	3,974,854
	Grand Total B.t.u.'s	103,596,214
Q	Total B.t.u. per hour	4,316,508
R	Total B.t.u. per ton of ice	332,039
S	Total tons refrigeration per ton of ice	1.15
	Average gage suction pressure, pounds per square inch	25.5
	Average brine temperature, deg. F.	15.0
T	Ammonia temperature corresponding to suction pressure	11.8° F.
U	Temperature spread, deg. F.	3.2
V	B.t.u. heat transfer per sq. ft. external pipe surface per hour	126.3
W	K heat transmission coefficient in B.t.u. per sq. ft. of external pipe surface per degree F. temperature difference per hour	39.46

To find the value of A, the total number of cans in the tank or tanks is divided by the tons of ice harvested each 24 hr. B is found by measuring the brine at two points five rows apart and subtracting the difference; C by measuring from the top of the tank to the ice, and from top of tank to brine and subtracting the difference.

To find the value of D, measure coils from radius to radius times pipe high times number of coils, plus lineal feet in bends and headers, if any, that are submerged in the brine. E is found by dividing D by tons of ice per day. To find the value of F, divide D by 2.3, as 2.3 lineal feet of 1¼ in. pipe equals one sq. ft. of external surface. G is found by dividing F by tons of ice harvested per 24 hr.

The value of H could be 306 for 300 lb. cans and should be checked each day or so. The value of I will vary depending on the air system employed, and the amount the cans are submerged, deep submersion produces a very thin core at the top of the cake and does not require a great quantity of water for filling. As a rule more water is required where the drop pipe system is employed, providing the pipes are removed before freezing in.

Old Plants

Value of J is based on the actual pounds of water put in the cans as that is the actual pounds of ice produced. For every ton of ice we freeze, there is 40 lb. extra to take care of bathing. In the office, however, we only get credit for 306 t. instead of 312 t., but these figures should be on the plant log sheet each day. If the management wants to raise the weight, the two sets of figures should be put on the sheet.

An old tank with short cans and no submersion can be made to produce more pounds of ice by cutting down the weight of the water. For example, at one time I operated an old plant where the shallow 60 t. tank contained 400 lb. cans, 58 in. long. We needed

more ice, and made a gain of 5 t. of ice per day by cutting the weight of water 25 lb. to get approximately 3 in. submersion and sold the ice for 375 lb. per cake. Of course, we pulled more cans and at the same time more ice, as we did not have to wait from 3 to 4 hr. for the wide cups to close up.

The value of L is found by dividing the total cans in the tank by the average number of cans harvested per hour. M is determined by a number of tests and in this case the temperature was found to be 18 deg. F., with a cup 2 to 3 in. deep in the cake.

To calculate N, first find the number of B.t.u.'s to be extracted per pound of water. With the initial water temperature 40 deg. F., $40 - 32 = 8$ B.t.u. per pound to cool the water to 32 deg. F. Then 144 B.t.u. must be extracted to freeze the water to ice at the same temperature, and since the latent heat of ice is 0.5, 7 B.t.u. per pound must be extracted to lower the ice from 32 to 18 deg. F. In this particular plant the number of cakes harvested per day was 1530, each can containing 408 lb., hence the B.t.u.'s for cooling and freezing would equal $8 + 144 + 7 \times (1530 \times 408) =$ 99,254,160.

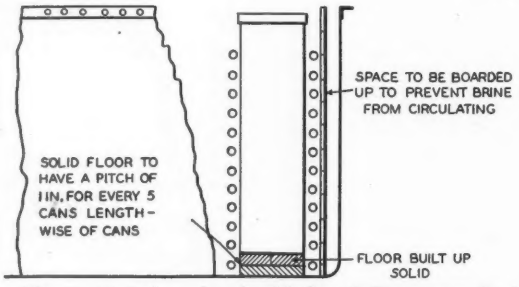

SPACE TO BE BOARDED UP TO PREVENT BRINE FROM CIRCULATING
SOLID FLOOR TO HAVE A PITCH OF 1 IN. FOR EVERY 5 CANS LENGTH-WISE OF CANS
FLOOR BUILT UP SOLID

Fig. 2. End view of tank with floor built up properly

The pull was 1530 cakes per day and with each can we pumped out 30 lb. of 32 deg. F. water, replaced it with 30 lb. of 40 deg. F. water making it necessary to remove 8 B.t.u. per pound additional from this water, giving $8 \times 30 \times 1530 = 367{,}200$ B.t.u. as the value for O. P is equal to 4 per cent of N + O, assumed as the losses due to radiation, tank floor, tank walls, covers and covers being off. Q is found by dividing the grand total B.t.u.'s by 24 hr. The value of R is the grand total B.t.u.'s divided by the gross tons of ice harvested per day and S is R divided by 288,000 B.t.u., the heat equivalent of one ton of refrigeration. The value of T is found in the ammonia tables and as the saturation temperature corresponding to 25.5 lb. gage pressure.

U is the difference between the temperature of the ammonia in the coils and the brine in the tank. The value of U is important as it indicates the efficiency. The nearer the brine and ammonia temperatures are to each other the higher the suction pressure. In this plant the ammonia was 11.8 deg. F. and the brine 15 deg. F., giving a difference of 3.2 deg. F. If the temperature difference had been 7 deg. F. instead of 3.2, with brine remaining at 15 deg. F., it would have been necessary to operate with 22 pounds suction pressure instead of 25.5, a difference of 3.5 pounds, with an extra cost for power of approximately 10 per cent per ton of ice. Some old tanks have a temperature difference of from 7 to 10 deg. F.

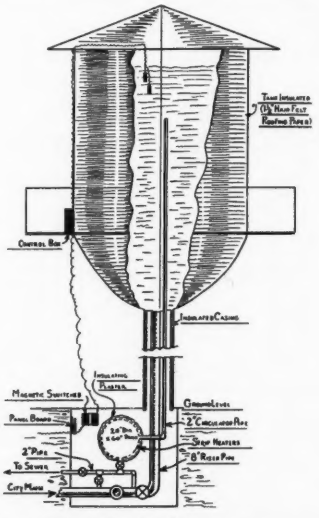
To find the value of V, divide Q by F, i.e. the B.t.u. per hour by the total sq. ft. of pipe surface. To find the value of W, or the heat transmission coefficient, divide V by U. The value of 39.46 heat transfer is considered very good for ice freezing tanks.

With a 7 degree temperature difference instead of 3.2 the value of K would be cut to 18. There are any number of ice plants operating under just such conditions. And instead of the power cost being 45 to 50 cents, it is no doubt 55 to 60 cents per ton of ice.

Water Tank Protection

A 30,000 Gal. Water Tank Used on a Sprinkler System Protected by Automatically Controlled Electric Heaters

SPRINKLER SYSTEMS, so widely used in manufacturing plants for fire protection purposes, are supplied by large storage tanks which in cold weather must be protected from freezing in order to maintain the effectiveness of the sprinkler system. Various methods have been tried at different places but electricity has been found effective by the Sheaffer Pen Co. at Fort Madison, Iowa. This installation is supplied with power from the Union Electric Light & Power Co. system, and the installation as described in their magazine is shown in the accompanying cut.



Water tank and strip heater arrangement

Heating is provided by twenty-four 500 watt electric strip heaters installed on an auxiliary insulated tank. The heaters and thermostatic control are arranged so that when the water temperature in the main tank reaches 55 deg. F. half of the heaters are cut in automatically and at 48 deg. F. the remaining half are cut in. The water storage tank has a capacity of 30,000 gal. and is located about 50 ft. from the main building and 60 ft. above the ground. The electric heaters have been in service for a number of years without attention except for the replacement of some of the heating elements. The tank itself is insulated by 1½ in. of hair felt and roofing paper.

Air Conditioning a Chocolate Plant

Blumenthal Bros. Double Producing Floor Area and Install Three Air Conditioning Units. By W. F. Schaphorst

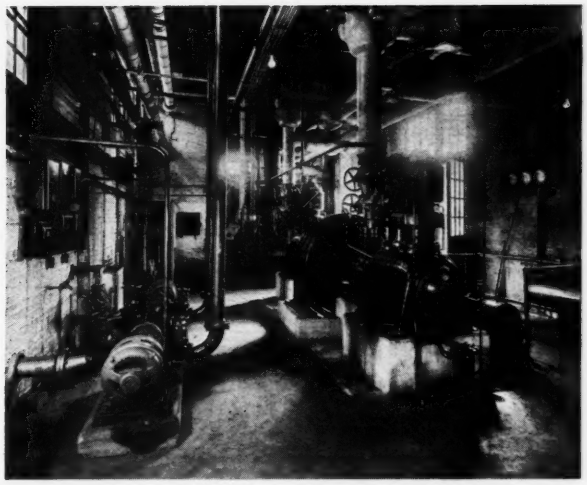


Fig. 1. The new refrigerating machine is installed in the power plant

BLUMENTHAL BROS., chocolate and cocoa manufacturers of Bridesburg, Philadelphia, have recently doubled their producing floor area by the installation of three air conditioning plants in their Building No. 2. Josiah H. Smith and Wm. G. R. Braemer, Philadelphia engineers, had entire supervision of the work.

All of the principal refrigerating machinery, compressors, pumps, condensers, etc., is located in the power plant building. A 1000 g.p.m. cooling tower is installed on the power plant roof and a De La Vergne vertical shell tube condenser, 42 in. in diam. and 16 ft. high, outside the building over a concrete tank made large enough for another condenser of equal size in the event of future abandonment of the old condenser which is still being used. Heat, refrigeration, electricity and water are supplied to the manufacturing departments from the power house through adequately insulated pipes and cables. The ammonia liquor line is 2½ in. in diam. and the suction line is 6 in. in diam.

Figure 1 shows much of the new refrigerating machinery. In the central foreground are two vertical duplex De La Vergne 10 by 10 in. compressors, driven by a single direct-connected 250 hp., 300 r.p.m., engine type Burke synchronous motor placed between the two units.

When desired the old refrigerating plant, visible in the background of Fig. 1, can be used with the new plant. The piping hook-up is such that the compressors can be operated on either 40 or 20 lb. suction pressure. With 40 lb. suction pressure the new ammonia compressors have a capacity of 192 t. of refrigeration, which, together with the 95 t. of the old compressors gives a total of 287 t. for handling future peak loads. A load of 81 t. will be added in the future so that during peak periods, will make it necessary to use the combined capacity of all compressors. The arrangement used makes it possible to operate either side of the new compressors on the high suction pressure from the new dehumidifiers, or from the low pressure of the old system.

At the left, Fig. 1, are the two 500 g.p.m. Buffalo pumps which pump the condenser cooling water from the tank beneath the condenser to the top of the cooling tower, about 52 ft. The maximum requirement during summer is 1000 g.p.m. In winter one of the pumps will be sufficient. Each pump is driven by a 15 hp. Lincoln motor. One end of the ammonia receiver is visible at the extreme right.

The new building, Plant No. 2, is 400 ft. long by 80 ft. wide and has three floors. Of the total floor area, about one-half is air conditioned at the present time and it is planned that this will eventually be extended to include most of the floor area.

On each floor there is a Braemer dehumidifier which accounts for the principal refrigeration load. Thus on the first floor, as well as on the other two floors, an area 200 by 80 ft. is air conditioned. To reduce heat loss and save refrigeration the air conditioned portion of each floor is enclosed by insulated partitions composed of 4 in. of tile, 2 in. of cork with ½ in. of plaster on both sides. The roof of the building is insulated with 2 in. of cork. All windows are equipped with double sash.

On the first floor chocolate products are wrapped and packed in a temperature of 65 deg. F. and a relative humidity of 50 per cent. The first floor also contains the offices in which a temperature of 76 deg. F. and relative humidity of 40 per cent are constantly maintained by additional apparatus. Air for the offices comes directly from the dehumidifier at a temperature of 44 deg. F. and by means of an Aerofin heater the temperature is raised to 76 deg. F. The method of most economically producing and maintaining the two temperatures on this floor has been ingeniously worked out by the engineers, allowing no unnecessary heat or refrigeration loss.

The Dehumidifiers

Chocolate products are also wrapped and packed on the second floor, at the same temperature and relative humidity, and Fig. 2 shows the dehumidifier which conditions all air used on this floor. In the design of the dehumidifiers all heat conditions were given full consideration: heat transfer through walls; heat given off by the operators employed on the floor; and heat generated by motors, lights, friction of moving machinery, etc. For the first and second floors the dehumidifiers are each designed for 15,000 c.f.m. of air and for the third floor, 17,500 c.f.m On the first and second floors the dehumidifiers atomize 192 g.p.m. of cold water and on the third floor, 294 g.p.m.

Dehumidifiers on the first and second floors are provided with two sets of sprays; on the third floor, three sets. A pressure of 25 lb. per sq. in. is maintained on the spray nozzles. Each dehumidifier is equipped with a V-Belt driven limit load Buffalo fan. To cool the water within the dehumidifiers a counterflow device is employed, water flowing downward and ammonia upward. All three dehumidifiers are set on a 2-in. cork mat laid in asphaltum cement and completely

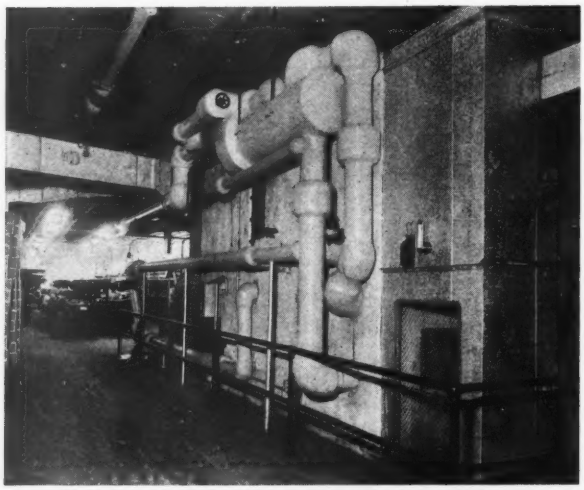


Fig. 2. One of the dehumidifiers installed on the second floor to maintain a temperature of 65 deg. F. and a relative humidity of 50 per cent

insulated with 2 in. of sheet cork covered with ½ in. of Portland cement. The cold water centrifugal pumps and piping are completely insulated with 2 in. of moulded cork covered with heavy canvas, sewed and enameled.

The third floor requires a higher capacity dehumidifier than the other two floors because various perishables, such as dried buttermilk in bags, raisins and nuts are stored there. For that reason a lower temperature, 52 to 60 Deg. F., is maintained and this can be varied from one limit to the other by means of thermostats. As on the other floors the humidity is maintained at 50 per cent.

Refrigerating equipment, such as compressors, condensers, receivers, oil traps, etc., was furnished by I. P. Morris & De La Vergne, Inc.; the cooling tower by the Harry Cooling & Equipment Co.; the dehumidifiers were built under the direction of Smith and Braemer by Wm. J. Strandwitz & Co. The Frick counterflow cooling coils in the dehumidifiers were furnished and installed by the Mack Machine Co.

All fans and centrifugal pumps were furnished by the Buffalo Forge Co. and all fans and pumps are driven by Lincoln Electric Co. motors. The fans, pumps, dew point and Power Regulating Co. temperature control, Webster thermostatic traps, Aerofin heaters, steam and return piping, etc., were installed by Wm. H. Walters & Sons. All suction and cold water pipe lines were insulated with Armstrong cork furnished by John R. Livezey and all electrical work was done by Silcox & Sons. Building construction was by Robert E. Lamb Co.

Reducing Fuel Costs

Use of Lower Priced Fuel and Forced Draft Offers Possibilities. By A. E. Seelig, L. J. Wing Mfg. Co.

ONE OF THE important expense items in the operation of any building is the fuel required for heating purposes so that this subject receives much attention from operators of heating plants. Naturally, no one irrespective of what their present system may be or how antiquated it is, is anxious to throw it into the discard and reinvest in completely new and more up-to-date equipment and anything they may be able to do at small expense, to lower operating costs is most welcome. The obvious solution is to burn cheaper fuel or to obtain greater efficiency from the fuel now being used.

The local means to this end is the equipping of the boiler furnace for burning the lower priced grades of coal which are often incorrectly believed to be of inferior quality. This is especially true with anthracite. A few years ago the anthracite operator graded his product as broken, egg, stove, and chestnut. What was left (about 30 to 40 per cent of the output) was considered as screenings or culm, to be thrown away, not because it did not contain the same amount of heat units, but due to the lack of a method whereby it could be burned economically.

Prices of the larger sizes of anthracite range from $9.00 to $14.00 per t., while the small sizes (buckwheat, rice and barley) cost from $4.50 to $8.00 a t. Obviously, by burning the smaller sizes (which contain practically as much heat as the large sizes), the building operator can make a big reduction in the coal bill. For example, a building where 100 t. of egg coal are burned annually can use small coal and save $5.00 a t., or $500 a year. Similarly, á building which now burns 500 t. of No. 1 buckwheat, can, by changing to rice or barley coal at a saving of $1.50 to $2.00 per t., save from $750.00 to $1000.00 a year.

As years rolled by and prices of anthracite advanced, the grate bar manufacturers began to develop grates to handle this former "waste". But a properly designed grate alone was not sufficient, other things were necessary. After much research and experimental work, it was found that the proper equipment for burning this fine coal consists of two distinct parts, an electric fan blower and pin hole air diffusing grates which are dumped instead of shaken to remove the ashes. The grates furthermore were provided with lapped sides and edges to prevent sifting.

The blower provided the necessary forced draft to distribute air through the fuel bed to burn the coal properly. The pin hole grates prevented leakage of

unburned coal and admitted air properly diffused for even combustion. As a further safeguard against uneven air distribution and to prevent the formation of blowholes in the fire, the fans were designed for delivering air into the ashpit at low velocities through discharge openings of large diameter.

Even steam pressure, maintained under all conditions and susceptible of being changed at the will of the operator, is supplied by means of an automatic controller, which stops the blower at the maximum steam pressure desired and starts it again when the pressure falls below a predetermined minimum level. Thus the fireman can set his steam pressure at from, say 4 to 5 lb. with the assurance that it will remain within these limits without attention between periods of fueling.

Besides the saving effected by burning a low instead of a high priced fuel, there are other advantages of minor importance but well worth considering. Much less time is required of the fireman, as it is not necessary for him to watch the steam pressure between fuelings, this being regulated by the automatic controller. The forced draft gives a quick fire and makes it possible to get up the required steam pressure in a much shorter time than with the natural draft.

Combustion is improved and the even heat produced by the automatically controlled draft is more economical than that produced by uncontrolled natural draft with which the steam pressure mounts and falls over a wide range, producing a wide variation in the room temperatures. Firing of a furnace with this type of equipment requires a technique slightly different from the old method but it is easily and quickly learned.

The best time to make the installation is during the summer when the furnaces are not in use but if installed during the winter it is necessary to remove the fire from the furnace for only about 8 hr. Where two or more furnaces are used in a building the installation can be made one at a time, thus maintaining heat in the building during the change-over.

As to the potential savings, as well as means and ways of obtaining the money to buy such equipment without exceeding the regular allotted budget, these are best illustrated by quoting the well-known head of a large Public Library in the East.

"Library appropriations being what they are, the question of how to obtain the money for the purchase of this equipment may arise. We found an easy solution to this problem. The cost of the equipment for our two furnaces was about equal to the saving which a fair estimate indicated that we could expect in one year's coal bill. Our budget was made up for the purchase of stove coal. We paid for the equipment from the coal fund and we expect to buy a year's supply of No. 2 buckwheat (rice) coal with the balance in the fund. Our budget allotted $1,050 for coal. The equipment cost $641, leaving $409 to purchase coal. At the current price of $5.50 a t. we can buy 74 t. of No. 2 buckwheat which is easily a year's supply.

"We are realizing an additional saving which we had not anticipated before installation. With the natural draft and large coal, two boilers operated to capacity were required to heat the building. Now with the forced draft one boiler does the work as well as two did before. This results in a saving in tonnage of coal used. While we have not used the single boiler long enough to have exact data on the fuel consumption, the day-to-day comparison indicates that the one furnace is heating the building on about two-thirds the quantity of coal required by the two when both were used. Thus we have cut our coal costs by about 50 per cent in price and an additional 33 per cent in tonnage.

"While we will realize little actual saving in the first year after deducting the cost of equipment, in succeeding years we should realize an annual saving of about $700 or a return on our investment of over 100 per cent annually."

Success in building operation requires taking advantage of every opportunity for minimizing all major items of expense. Modern engineering science having perfected means for the utilization of low-cost small anthracite as herein described, failure to make use of this opportunity and continuation of the use of the uneconomical fuels commonly employed for heating in the past, constitutes an economic waste and a direct and entirely needless loss of money which the more alert owners and managers of properties with steam heating plants have learned to keep in their own pockets, wherever small anthracite fuel is available.

Flood Lamps Combat Numb Fingers

By Kermit B. Hoffman

DURING a recent cold spell employees of the "Maintenance Division" were called upon to make quick repairs to a cable connecting to a large size 2.3 kv. motor installed in a tower. The failure had occurred in a compound-filled terminal located outside the motor enclosure and mounted on a fabricated support.

The cold was intense and high winds whistled around the tower. A new terminal had to be installed plus what additional splicing was necessary.

A temporary canvas tent was arranged which broke the wind somewhat, but the intense cold continued and as the work progressed it was realized that something had to be done to warm the hands of the men if a first class splicing job was desired. Incidentally, the job could not be postponed until weather conditions were more favorable because the motor was needed immediately.

A hurry call was sent throughout the plant for heating reflectors, with no success. Then it was decided to utilize the adjustable flood lamps used in the shops when rewinding armatures or when making other repairs to motors and generators. Socket adaptors were installed with suitable heating elements. The lamps were then focused directly on the terminal and splice and the job was finished on schedule and minus numb fingers. A dielectric test conducted before the motor was put back in service showed the terminal and splice satisfactory.

As One Engineer to Another—

Heat Transfer Problems Made Easy By a Fundamental Formula. By G. F. WETZEL, M.E.

DO YOU believe in magic keys, Chief?" I asked my friend the operating engineer of the Radburn Company as we started another of our discussions of problems pertaining to his work. He looked at me as if to inquire whether I had suddenly lost my mind.

"No fooling, Chief," I said. "Here is what might really be called the magic key to most of the problems involving heat quantities," and I quickly wrote on the back of a business card and held it up so he could see it:

$$H = CW(t_1 - t_2)$$

where H is heat in B.t.u.

C is specific heat
W is weight of solid, liquid, or gas (or vapor)
$(t_1 - t_2)$ is temperature difference

"This general equation is basic in expressing heat quantity relationships. Sometimes 'H' is rather an involved expression, and there may be complications in evaluating the right hand side of the equation, but regardless of the number of terms required it all comes down to our 'magic key.'"

"Maybe you know what you are talking about, G. F.," the Chief remarked, "but you will have to do some explaining to make me believe it. First give me a clear definition of specific heat. You mentioned it during our last session, but there were so many things to think about that I forgot to ask about it."

"Specific heat," I replied, "is the amount of heat, expressed in B.t.u., required to raise the temperature of one pound of a solid, liquid, or gas, one degree Fahrenheit. The term 'gas' would include superheated vapors. You remember that the specific heat of water is practically one B.t.u. Every other substance has a specific heat of less than one B.t.u. Air for example, has a specific heat of 0.2415, usually taken as 0.24 which means that 0.24 of one B.t.u. will heat one pound of air one degree.

"Three other terms with which you should refresh your memory are—specific weight, specific gravity, and specific volume. Specific weight is the weight of unit volume. For liquids, vapors and gases it is usually given as the weight per cubic foot, and for solids may be expressed as weight per cubic foot or per cubic inch. For example, one cubic foot of air at 70 deg. F. weighs 0.075 lb. and this is its specific weight for that temperature. Specific gravity is the comparison of the weight of a given substance with the weight of an equal volume of water. It is used in connection with solids and liquids. Specific volume is the volume of unit weight. Gases and vapors have their specific volume expressed in cubic feet per pound. Liquids and solids will usually be measured in cubic inches per pound.

"These three terms,—specific heat, specific weight, and specific volume, particularly, should be thoroughly understood because they are used in so many calculations, and unless correctly used it will just be a matter of luck if you get the right result."

Oil Heating Problem

"I think you put those definitions pretty clearly, and that I have them fairly well in mind. Suppose we apply them in some problems," the Chief suggested. Glancing out of the office window I saw a neighboring plant unloading a carload of fuel oil, using steam to heat it up to speed the flow in the discharge pipe, and called his attention to it.

"There is a problem for you, just made to order. Take this down: How many pounds of steam at 5 lb. (gage) pressure will it take to heat up that carload of oil from 50 to 100 deg. F.? It looks like an 8000 gal. car. The specific gravity will be about 0.8. The specific heat will be approximately 0.55 B.t.u. per pound.

"Remember the magic key. Here is a chance to use it. We will build up an equation using the values we know, and the unknown value, which we do not know, we will call 'X' and use it in forming the equation just as if we did know it. Then when our equation is completed we will rearrange it to get the unknown quantity on one side, and the known values on the other side, then all that is necessary is a little arithmetic, and we get the answer."

The Chief interrupted here with,—"Simple, isn't it, —for whom?"

"Just skip the sarcasm, Chief, and listen, and I will try to make it understandable even for your limited intelligence.

"In this case the unknown is the pounds of steam. We will assume that the steam is dry and that we use only the latent heat. The heat given up by the steam will exactly equal the heat absorbed by the oil, except for that lost through the steam pipes, and by the tank, which we will neglect in this problem.

"Look up the latent heat of steam at 5 lb. gage or 20 lb. abs. (near enough for practical purposes." He gave me the value 959.9 B.t.u. which we used as 960 B.t.u. per pound.

"Now we are ready to write down our equation. If we need 'X' pounds of steam and each pound has available 960 B.t.u., what will we put down for 'H'?"

The Chief was intensely interested and was follow-

ing the problem closely, so he was ready with the value which he put down as "960 X."

Finding Heat Added to Oil

"Now let's get the other side of the equation. This will be weight of the oil times the specific heat times the temperature difference through which the oil is heated. Therefore,—

$$960\,X = 8000 \times 0.8 \times 8.33 \times 0.55 \times (100 - 50)$$
$$X = 8000 \times 0.8 \times 8.33 \times 0.55 \times 50 \div 960$$

"Have you got that all down, Chief? Let me call your attention to a few points about doing problems like this. You will notice that while the problem is solved we have done no arithmetic yet. To complete the solution and get the final answer, we merely evaluate the fraction on the right side of the equation. There are several sound reasons for getting it all put down before doing any calculating. In the first place, having all the individual figures we can easily check back for both accuracy and completeness. For example, 8000 is the number of gallons, 0.8 is the specific gravity and this multiplied by 8.33 (the weight of a gallon of water) gives the weight of the oil in pounds, 0.55 is the specific heat, (100 — 50) is the temperature difference through which the oil is heated. Thus we have taken into account all the factors of our 'magic key'—W, C, and $(t_1 - t_2)$.

"Another important reason for putting down all the figures in one fraction is that in most cases considerable cancelling and combining can be done which will save a lot of arithmetic, time, and chances for errors. Just to illustrate, Chief, you go ahead and solve the equation your own way, and I'll do it along the lines I described, then we will compare the results."

After allowing him time to carry out his calculations, he showed me a whole page full of figures.

"I am strongly tempted, Chief," I told him, "to get sarcastic and tell you what I think, but I'll let you say it yourself in a few minutes. Look!" and I showed him my paper.

"You saw this problem 'grow' right before your eyes so you know it was not picked out to bring in some trick figures. Follow it through with me and see how simple it becomes. In the fraction

$$\frac{8000 \times 0.8 \times 8.33 \times 0.55 \times 50}{960}$$

we can cancel out a cipher in 8000 and 960; we can divide 8 out of 800 and 96; we can mentally multiply 0.8 by 50 and write the fraction like this:

$$\frac{100 \times 8.33 \times 0.55 \times 40}{12}$$

then divide 4 out of 40 and 12, multiply the resulting 10 and the 100 leaving: $8330 \times 0.55 \div 3$. Multiply 8330 by 0.55, and then mentally divide by 3, and put down the answer: 1527.2 lb. of steam."

The Chief started to say something,—changed his mind—and finally blurted out, "I'm speechless, G. F.!"

"Oh, no, you're not, Chief," I answered. "You are just a little ashamed of yourself for running 'circles around,' instead of using that so-called mind of yours, which I know you are perfectly capable of doing if some kind friend, you know, like me, calls your attention to it."

Fuel Oil Required to Heat Oil

"This problem suggests another one:—How many gallons of oil will it take to heat the tank car of fuel oil if it requires 1527.2 lb. of steam. We will assume a boiler efficiency in your neighbor's plant of 75 per cent and a calorific value for the oil of 148,000 B.t.u. per gal. Here again we can build up an equation; the heat in the steam equals the heat utilized out of 'N' gallons of oil. See if you can carry it through by yourself, while I sit and day-dream for ten or fifteen minutes. Remember, you don't care where the unknown quantity comes, just write down all the factors that enter into the problem, using the unknown just as if you knew its value. Then when the equation is complete and checked, rearrange it to get the unknown on the left of the 'equal' sign and all the known values on the right. Then cancel out all the ciphers you can, and the easily seen figures, do one or two small multiplications, and, or, division operations, and there is your answer. 'What could be sweeter'?"

I closed my eyes and must have dozed off for a moment when I was suddenly brought back to earth by the Chief's voice.

Too Bad—You're Wrong

"Here, G. F., check this equation, then tell me how to get 'N' over where it belongs." He handed me this:

$$960 \times 1527.2 = \frac{148{,}000 \times N}{0.75}$$

and went on to explain each figure.

"960 is the number of B.t.u. per pound of steam, and this multiplied by the number of pounds gives 'H', the heat quantity, which is equal to 148,000, the number of B.t.u. in a gallon of fuel oil times the number of gallons which we do not know, and so we put down 'N'. Then to allow for the efficiency we divide by 75 per cent or 0.75. Now show me how to find 'N' and we will be through with it."

"I'm sorry to say so, Chief," I commented, "but though your reasoning on the whole is very good, you made a slight error. But don't feel bad about it because it is a very common mistake. You got your efficiency figure in the wrong place. In all problems of this kind the efficiency value must be placed where it will increase the amount of fuel over what it would have been if the efficiency were 100 per cent. 148,000 divided by 0.75 would be 197,300 and you know this is not the number of heat units utilized per gallon, if there is only 148,000 to start with. Let's rewrite it like this:

$$960 \times 1527.2 = 148{,}000 \times 0.75 \times N$$

"Putting it into words we have: Heat in the steam is equal to the heat utilized per gallon of oil times the number of gallons.

"Answering your question about solving for 'N' we will divide both sides of the equation by '$148{,}000 \times 0.75$' thus:

$$\frac{960 \times 1527.2}{148{,}000 \times 0.75} = \frac{148{,}000 \times 0.75}{148{,}000 \times 0.75} \times N = N$$

or transposing—

$$N = \frac{960 \times 1527.2}{148{,}000 \times 0.75}$$

"Here is another chance to practice simplifying a fraction. We can divide by '40' giving us—

$$N = \frac{24 \times 1527.2}{3700 \times 0.75}$$

Dividing by '4' mentally we get—

$$N = \frac{6 \times 1527.2}{925 \times 0.75} = \frac{8 \times 1527.2}{925}$$

or 13.2 gal. Thus you see how simple it can become just by using your eyes to see where the various factors can be divided by the same number. Just a word of caution should be given here: If there are any additions or subtractions in your fractions, the safest plan is to find the total value of the numerator and divide by the total value of the denominator."

Water Requirements of Condenser

"Another application of the 'magic key' is illustrated by a condenser problem. How many gallons of water will be required per minute to condense 12,000 lb. of steam per hour at 25 in. vacuum. Allow a temperature rise of 20 deg. in the water. Look up the latent heat and temperature of steam at 25 in. of vacuum."

He read from his steam tables—"Temperature 134 deg., latent heat, 1017.0 B.t.u." and added, "I'm going to try to work this right the first time, and think out loud so you can check it as we go along."

" 'H' will be the amount of heat. We have given the pounds of steam per hour, but the answer is wanted in gallons per minute so we must divide by '60', so 'H' will be $\frac{1200 \times 1017}{60}$ and thus will be equal to $WC(t_1 - t_2)$. 'W' in G. F.'s magic key is in pounds, but we want the answer in gallons, so I will use 'G' for the number of gallons,—and since $W = 8.33 \times G$, there being 8.33 pounds of water per gallon, I will put that in. 'C' the specific heat is '1' for water so we can leave it out. $(t_1 - t_2)$ is the temperature difference which was given as 20 deg.; so the equation will be:—

$$\frac{1200 \times 1017}{60} = G \times 8.33 \times 20$$

$$G = \frac{1200 \times 1017}{60 \times 20 \times 8.33} = \frac{1017}{8.33} = 122.1 \text{ gal. per min.}$$

"There, G. F.," the Chief exclaimed when he had finished. "How'm I doin'?"

"I'm proud of you, Chief," I returned. "You certainly are an apt pupil. But now I think we better stop a moment and see what we are doing. You were rather skeptical when I first gave you what I called the 'magic key.' Of course it is nothing but the algebraic expression of the make-up of a heat-quantity, though I believe if you think of it as the key to nearly all heat quantity problems, you will be able to analyze them and solve them. Every operating man should be able to do almost any heat quantity problem that comes up. And this ability will many times enable him to make minor changes that may make appreciable increases in the over-all plant efficiency, get at the costs of heat exchange operations, and generally enable him better to understand just what he is really doing."

Inspection *of* Metal *with* RADIUM

Interesting economic considerations in the practical use of radium

By J. F. SPRINGER

RADIUM inspection of castings, forgings, etc., is not exactly new. As far back as 1929, the practicability of using gamma rays for the inspection of metal objects was demonstrated. Now we do not have to employ radium itself. Radium emits gamma rays and they are really the thing wanted. As a matter of fact, these rays may be obtained from radon, otherwise known as emanation gas. This gas is not radium, but it is the child of radium. Mesothorium is another source of gamma rays. This mesothorium is a by-product obtainable by the working of monazite sand when the object in view is to obtain thorium for employment in the manufacture of incandescent gas mantles.

That gamma rays, from one source or another, are going to be used practically in industry, is indicated by two principal facts: (1) Gamma rays are effectively penetrative beyond X-rays. They are, for example, capable of penetrating metal thicknesses up to, say, 10 in. and then producing a record of the conditions encountered. (2) Gamma rays are emitted from a tiny central "focus" and proceed in all directions with uniform intensity, so that it is possible to get radiographs simultaneously of a multitude of objects placed anywhere and everywhere at the ends of radii.

Gamma rays are not cheap, whether we get them directly from radium or not. That they are practical seems highly probable. That is, they can do their job. The question remains whether they are also practical from the point of view of cost. It has been calculated that $2.60 will be the cost per hour, radium and labor, for the use of 1 gram of radium. This is on the basis that the 1 gram is used 6000 hr. per year—that is, 24 hr. per day for 250 days. For steel 3 in. thick, the cost might be around 0.2 cents per pound for radium and labor. Films and chemicals, whether gamma rays or X-rays, would add, say, 1 cent per pound. So that the complete cost figures out about 1.2 cent. For small objects, the cost for radiographs is, naturally, to be divided up among the lot.

Case Studies in Power Economics

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

REDUCING DEMAND CHARGE BY SCHEDULING

IN THE PURCHASE of electricity, especially in large quantities, there will enter two charges: the energy charge and the demand charge. The energy charge is a commodity charge and of course the more that is used, the greater is the amount the user has to pay for it. The demand charge on the other hand is a so-to-speak "readiness-to-serve charge" and it is established by the maximum amount of power required during a given short interval. With most utilities this interval is about thirty minutes in any one month. While the energy consumption, upon which the energy charge is based, is usually in proportion to the amount of production during a given time, the demand, upon which the demand charge is based, is in reality an indication of the degree of concentration of operation.

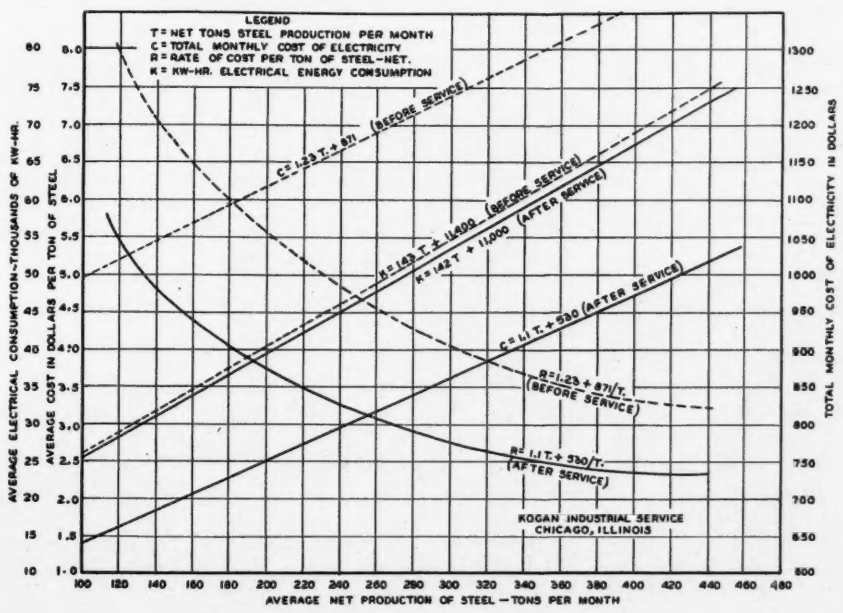
The concentration of operation may occur in different plants at various intervals. In one plant the concentration of operation may be in a period of 8 hr., in others in a period of 5 hr. and in others a period of 2 hr. By this is meant that one plant may have all of its heavy equipment operating a given hour during the day and thus concentrate a considerable portion of its operation during that hour and thus establish a very high demand.

Since the demand charge usually constitutes a very large portion of the bill it is highly important that the demand charge be reduced. This reduction in demand, however, can be obtained by spreading the operation over a longer period of time and thus eliminate the concentration of operation in one given short interval of the day.

The following is an illustration of the effect of concentration of operation on the demand:

When two punch presses, each driven by 10-hp. motor, operate at practically full load for 1 hr. simultaneously and turn out about 5000 articles in 1 hr., the energy consumption by each machine is approximately 7½ kw-hr. per hour and the demand established, that is the rate of power at which they are operating, is about 7½ kw. Hence, the demand established in the hour would be 15 kw. for both of them, with a total energy consumption of 15 kw-hr. Now assume further that only one punch press is operating for 1 hr., then the other punch press is operated the next hour, thus spreading the operation of these two machines over 2 hr. During that time, the energy consumption of this machine is again 7½ kw-hr. or a total for the 2 hr. of 15 kw-hr., turning out the same amount of work. Since the highest demand per hour, however, is only 7½ kw., the power demand, therefore, is only 7½ kw. In other words the demand is halved.

This particular illustration shows the advisability of spreading the work over a longer period of time, if the desire is to reduce the electric bill through the reduction of the demand charge. We have made a similar arrangement in the plant of one of our clients


LEGEND
T = NET TONS STEEL PRODUCTION PER MONTH
C = TOTAL MONTHLY COST OF ELECTRICITY
R = RATE OF COST PER TON OF STEEL—NET.
K = KW-HR. ELECTRICAL ENERGY CONSUMPTION
C = 1.23 T + 871 (BEFORE SERVICE)
K = 143 T + 11400 (BEFORE SERVICE)
K = 142 T + 11,000 (AFTER SERVICE)
C = 1.1 T + 530 (AFTER SERVICE)
R = 1.25 + 871/T. (BEFORE SERVICE)
R = 1.1 T + 530/T. (AFTER SERVICE)
KOGAN INDUSTRIAL SERVICE
CHICAGO, ILLINOIS
AVERAGE ELECTRICAL CONSUMPTION—THOUSANDS OF KW-HR.
AVERAGE COST IN DOLLARS PER TON OF STEEL
TOTAL MONTHLY COST OF ELECTRICITY IN DOLLARS
AVERAGE NET PRODUCTION OF STEEL — TONS PER MONTH

Reduction in cost of power effected by rearranging schedule

whose electric bill seemed to be inconsistent with the amount of production.

In this survey, at a steel casting foundry, we found that while the production dropped to 25 per cent of that of 1929, the electric bill was not reduced materially. In analyzing the electric bill we found that the energy consumption dropped practically in the same proportion as the drop in production. The demand, however, remained practically the same, i.e., the demand dropped only about 8 per cent.

This 8 per cent reduction in the demand was caused by the fact that a few pieces of equipment were not used at all, such as one tumblast and some swing grinders.

While producing a total of 780 tons per month in 1929 the demand was approximately 300 kw. During the period of our survey and subsequently, the production per month was only about 200 tons with a demand of approximately 280 kw.

We found that the reason for this almost fixed demand was due to the fact that our client was adhering to the same schedule of operation as used during a time when the output was very high. The plant was in operation around 5 hr. per day, from seven in the morning to twelve at noon. During 1929 the plant was operating about 20 hr. per day.

This arrangement immediately showed us that by spreading the work done in 5 hr. over a longer period, a considerable reduction in demand could be obtained.

Our client's load could be divided in the following departments with the respective connected loads in horsepower:

Foundry, with a total of 275 connected hp.
Annealing, with a total of 33 hp.
Welding, with a total of 52 hp.
Cleaning, with a total of 218 hp.
Machine shop, with a total of 37 hp., of which only 10 hp. were used.
Patterns and core rooms, with a total of 13 hp.
Yard, with a total of 25 hp.

In addition to the above they had service equipment such as the sump pumps, water pumps, etc., operated all the time with a total of 75 hp.

The total connected load in these departments was about 626 hp., not including the 75 hp. used for plant service, and also not including a 75 hp. air compressor which was used as an auxiliary and supplementary air compressor to a 200 hp. Diesel air compressor.

The compressed air was required to supply air for atomization in the open hearth furnace and also necessary for sand blasting and allied operation.

In order to reduce the demand we subdivided the several departments into two groups, each group containing all the departments, the simultaneous operation of which was absolutely necessary. We arranged the program so that the operation of one group did not coincide with the operation of the other.

This arrangement consisted in operating the foundry, the yards, core and pattern shop in the morning. This gave us a total of 313 hp. In the afternoon, for another 6 hr. the other group, consisting of the cleaning department with 218 hp., the annealing department with 33 hp., the machine shop with 10 hp. and the welding department with 52 hp., or a total of 313 hp. was operated. Hence, the load for the operating department was divided evenly.

By spreading the work over a 10-hr. period instead of the original 5 hr. period, the demand charge was practically reduced to half.

In this operation our client was able to reduce his demand charge by an amount equal to that established —by about 313 connected hp. Previously, when they operated the two groups together the demand of the one group was superimposed over the other. Now with spreading it over a longer period and arranging for the operation of one group so that it does not coincide with that of another he has been able greatly to reduce the demand charge.

The reduction of the demand charge amounted to about 150 kw. which at the rate of $2.00 per kw. meant a saving of $300 per month.

Another advantage in this subdivision of groups was that the necessity of the 75-hp. air compressor was entirely eliminated because the Diesel air compressor was of sufficient capacity to supply air to either the annealing department for sand blasting or to the foundry for oil atomization and for door lifting on the open hearth furnace. Hence, the demand established by the electric air compressor was eliminated. Besides, of course, there was also a reduction in the consumption of electric energy due to the elimination of the operation of this air compressor.

The effect of spreading the load to reduce the demand is clearly illustrated in the accompanying graph.

One can see that there is a slight difference in the energy consumption per ton before and after this spread. Under ordinary conditions there is no difference, but in view of the fact that in this plant an air compressor could be dispensed with, by allowing a Diesel engine compressor to assume the load of two operations at different times, a reduction in energy is shown. The greatest reduction, however, is shown in the total cost of power as in this case the demand charge, which represented the major portion of the power bill, was materially reduced. Similarly it is true of the electrical cost per ton of steel as the cost per ton curves are merely the reciprocal of the total cost curves.

WORK WHICH HAS BEEN GOING ON for the past 3 yr. under the direction of the A.S.T.M., the A.E.P.S. and the Bureau of Standards has reached the state where specifications on the plated coatings on iron and steel are about ready for approval. About 7000 panels were exposed, plated in almost every way known to the plating industry and some very important facts were discovered. It was found that the plating usually used was considerably less in thickness than should be required in accordance with the findings of the test. Adoption of the specifications by industry is an important matter involving the use of materials such as nickel, copper, zinc and cadmium, used in plating. Due to increased quality which will result from conformity with the requirements, the use of plated products will probably be increased. In the specifications two types of coating are covered, namely, coating for general service and coating for mild service. The requirements involve manufacture, thickness of deposits and methods for thickness measurement.

Readers' Conference

Water for Pump Packing

THE CENTRIFUGAL condensate pump serving our surface condenser, although a new one, gave us much trouble by drawing air through the suction end shaft packing. The seal ring was piped from the first stage and although the piping was clean, air would enter, destroy suction and the pump would not remove condensate until a head was built up in the condenser. Also the vacuum would drop considerably at these times. As you know, even a 1 in. drop on a heavily loaded turbine means a lot of extra steam.

This made it necessary to draw up packing many times a day in order to hold our 29.4 in. of vacuum. In fact, the moment the vacuum started to drop, a mad dash to the auxiliary basement was the regular thing. The packing had to be renewed every week end.

In overcoming this troublesome work, I piped city water from the turbine shaft seal line (15 lb.) to the pump suction seal ring of the pump. Now I enjoy practically trouble-free service with long times between packings.

Tacoma, Wash. EDW. A. HANSEN.

Two Power Saws Constructed for $7.00

TO BEGIN, I purchased an old but rugged kitchen table from a second-hand furniture dealer for the large sum of 50 cents. Having carefully removed the top, which was in one piece, I strengthened it by attaching battens to the bottom near each end and near the middle. These battens are necessary since the top is hinged at one end to allow it to be raised it order to change saws easily.

Next, shelf "A" was mounted about six inches above the floor by bolting suitable crosspieces "B" and "C" to the legs and bolting boards to these crosspieces. This shelf not only gives added strength to the table but serves as a mounting for the motor and other moving parts as will be seen. It may be well to state here that the motor "D" is a second-hand washing machine motor rated at ¼ hp. and was obtained for $3.00. It will be best to enclose the motor in a sheet iron box to keep out sawdust.

From a Kresge store I obtained a polishing head "E" of the well known "Driver" (Walker-Turner Co.) workshop equipment. At the same time I obtained one 6-in. circular cross-cut saw and one 6-in. circular rip saw "F", these three items costing $3.00. A crosspiece "G" between the table sides serves as a mounting for the polishing head, the crosspiece making an angle with the vertical so as to make the saw blade protrude through the table top as much as possible. Although my saw does not have this feature, it would be simple at this point to add a screw adjustment for raising and lowering the saw for deep or shallow cuts.

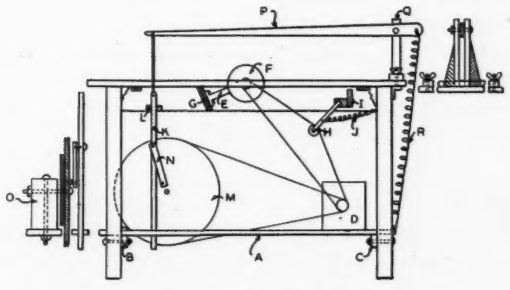


Fig. 1. Details of home-made power saw

All that remains to be done is to belt the motor to the polishing head, put the saw on and replace the table top after cutting a slit for the blade. I did this with the circular saw itself by carefully bringing the table top down into contact with the saw and allowing it to cut its way through at the desired place.

Due to the fact that even the best belt stretches in time, it will be well to arrange an idler pulley "H" such as shown to keep the belt taut at all times. The idler pulley suspension is hinged to another crosspiece "I" and the tension on the belt is maintained by a piece of screen door spring "J."

The jig saw details are fairly simple also. A true up and down motion for transmitting the power to the saw is obtained by using a square wooden piece about ⅝ in. square by about 2 ft. long "K" which moves up and down in square holes in the lower shelf and in another crosspiece "L" mounted as shown between the table sides. This crosspiece should be mounted flush with the bottom of the table sides so as to allow about 4 in. space between it and the table top for up and down movement and for saw mounting.

A large wooden disc "M" (15 in. diam.) in the edge of which a groove is cut for a sewing machine belt serves the purpose of reducing the motor speed and increasing the power and also furnishes a mounting for a bolt set off center about ½ in. to 1 in. to provide an eccentric. A connecting link "N" of hard wood rides this bolt and another in the vertical member.

The wooden disc is battened to prevent warping and to provide a better bearing and prevent wobbling. A piece of 2 by 4 in. or 4 by 4 in. "O" bolted to the shelf and drilled at the proper point furnishes the support for the disc whose shaft consists of a long 5/16-in. carriage bolt.

Due to the lack of sufficient clearance between the shelf and the crosspieces under the table top I found it necessary to cut a slot in the shelf allowing the disc to extend below about 2 in. I later found

this had another advantage of steadying the disc by transferring some of the strain on the bearing in making a deep cut with the saw.

The positions of the disc and the motor pulley are such that they are in line, as is also the polishing head pulley, making it simple to slip the circular saw belt off the motor pulley and slip the jig saw belt on and vice versa.

The top support for the jig saw simply consists of a long rocker arm "P' fastened to a removable support "Q" at the one end of the table. In my saw I confined the up and down motion to 1 in. and thus

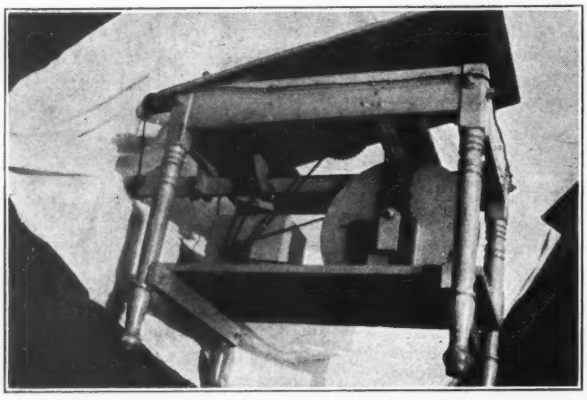


Fig. 2. View of power saw

the arc traversed by the upper long arms approximates a straight line very closely. The upper arm exerts a tension upward on the saw blade due to a piece of screen door spring "R" attached to its far end and to the shelf below the table.

Due to the fact that this design necessarily increases the motor load by increasing the spring tension I found it impossible to put sufficient tension on the ordinary scroll saw blade to prevent its breaking in use. However, pieces of discarded band saw blade (drilled at each end for mounting) proved ideal. A slit in the upper and lower saw supports with a bolt through them holds the blade securely.

To prevent bending of the saw when making a heavy cut I mounted three small rollers flush with the table top against which the blade rides and which do not permit it to bend either backward or sideways when pressure is exerted on it.

All of the material for the jig saw except a few bolts, the sewing machine belt and the pieces of band saw can be found in most anyone's workshop. The pieces of band saw can be obtained free of charge at most any sash and door or woodworking shop. The belt costs no more than 25 cents new, less if you can get a used one. It is, therefore, clear that the entire equipment for both saws can be constructed for about $7.00, depending primarily how much is paid for the motor. Even the wooden disc for the jig saw was cut out and grooved at home on the circular saw, the circular saw having been finished first. By making a number of straight cuts tangent to the circle first, the disc may be finished by revolving it around a nail through its center and driven into the table top.

La Crosse, Wis. VERNON W. PALEN.

Baffle Changes Reduce Boiler Maintenance

REFERRING TO THE ARTICLE by Julian E. Tobey entitled "Baffle Changes Reduce Boiler Maintenance," on page 330 of the July, 1934, number of Power Plant Engineering, the article has been read with great interest by this writer and has been discussed with an engineer who has devoted much of his life to the baffling of boilers. Both of us are unable to understand why the baffling as shown in Fig. 4 should give better results than Fig. 3, provided Fig. 3 was constructed as indicated. In fact we are inclined to doubt that the baffling even of Fig. 2 could properly be blamed for the tube trouble.

Newark, N. J. W. F. SCHAPHORST.

EDITOR'S NOTE: Mr. Schaphorst asks a number of questions which were referred to Mr. Tobey and which appear with his answers below. The article deals with baffle changes made on bent tube boilers by the author while chief engineer of the Studebaker Corp. at South Bend, Ind. Three of the illustrations from the original article are reproduced for reference. These changes were made to correct tube failure difficulties from buckling. The changes shown by Fig. 3 did not correct the difficulties and measured tube temperatures ranged from 800 to 1250 deg. F or from 400 to 800 deg. F. above the steam temperature, indicating dry tubes. Changing to the arrangement shown by Fig. 4 reduced the metal temperatures practically to steam temperature. At the same time the draft loss, from Fig. 2 to Fig. 4, from 0.85 to 0.45 in. of water at 225 per cent rating without any increase in exit gas temperatures. Mr. Tobey is now manager of the Fuel Engineering Division of Appalachian Coals, Inc. His reply follows:

FOLLOWING ARE ANSWERS to Mr. Schaphorst's questions about Baffle Changes Reduce Boiler Maintenance appearing on page 330 of the July, 1934, issue of Power Plant Engineering, and particularly to Mr. Schaphorst's questions pertaining to same. For clarity the questions are separated as nearly as possible and answered individually.

Q. There are a number of things that are not clear. Mr. Tobey does not state that the tubes in Fig. 3 were as seriously buckled as in Fig. 2. It hardly seems possible for the tubes to bend as much in Fig. 3 as in Fig. 2 because in Fig. 3 they are partially held in place by the baffle wall.

A. The tubes were buckled much more seriously under arrangement Fig. 3 than they were under arrangement Fig. 2. The reason for this condition was that arrangement Fig. 2 had two advantages in the front bank over arrangement Fig. 3, namely: (1) gas swept the front bank more thoroughly, thus applying heat to better advantage, especially to the

lower ends of the tubes in the rear of the front bank; (2) the superheater as located in Fig. 2 did not confine or localize the heat on the upper portions of the tubes in the front bank, especially on rows Nos. 4-5-6-7. Furthermore, the buckling occurred above the baffle wall for, as can be seen in photograph Fig. 1 (not reproduced), the lower portion of first bank is the cause of a "dead space" owing to the two opposing gas currents that have been set up. Dead spaces, of course, are of no value in any boiler.

A. The trouble was not due to scale or soot. This can be definitely proven by the conditions under which the thermo-couples were installed.

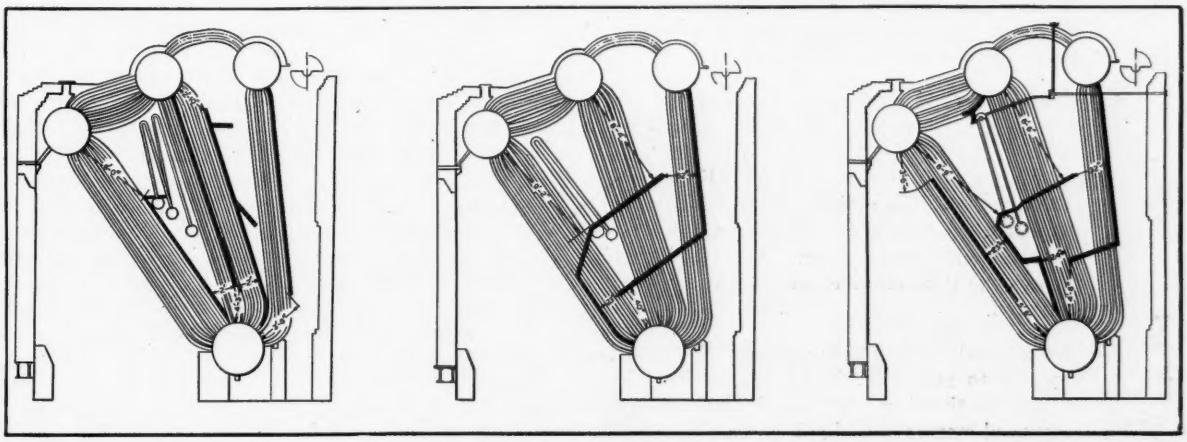


Fig. 2. Baffling arrangement as originally installed

Fig. 3. Arrangement which did not correct conditions

Fig. 4. Arrangement which proved satisfactory

each tube was comparatively straight. This buckling was due to overheated metal.

Q. Nor does Mr. Tobey state that the tubes shown in Fig. 3 were removed. Were the tubes removed before installation of the baffle walls in Fig. 3? Were they also removed just before the installation of the baffle walls as shown in Fig. 4? Or, was there only one removal of tubes?

A. Except for occasional tube replacements, due to this same condition, no wholesale tube replacements were made until baffle arrangement shown in Fig. 4 was installed. It was necessary at that time to replace the warped tubes for two reasons: (1) The tubes were badly deteriorated; (2) they interfered with the installation of the new baffles.

Q. It is quite possible that the trouble experienced was not due at all to the baffling, but was due rather to scale in the tubes, to soot, or to some other influence not shown in the sketches, which prevented the water from properly circulating through the tubes. There surely is just as much heat in the furnace in Fig. 4 as there was in Fig. 2. There is just as much radiant heat. It isn't likely that the tubes closest to the fire in Fig. 4 are absorbing more heat than they did in Fig. 2 and the fact that the rear tubes of the first bank are not buckling now is merely evidence that they are absorbing heat now, whereas formerly they didn't. Were they full of scale before? Now, of course, they are clean because they are new. A study of Fig. 4 shows clearly that the isolation baffle wall in the

In every instance it was impossible to get into the tube bank and weld the thermo-couple elements on to existing tubes. Therefore, it was necessary to install new tubes with thermocouple elements attached. The thermocouples showed the tubes to be dry under baffle arrangements shown in Fig. 3, whereas they were flooded under arrangement as shown in Fig. 4. It is not believed that any point can be made of a so-called dead space caused by the confluence of the two gas streams for the horizontal stream expands as it passes through the upper throat opening, and the vertical stream strikes the horizontal flow at right angles. Assuming there was created a small pocket or dead space, there are numerous dead spaces in every boiler due to corners, shrinkage of gas volume, etc., and as there was no increase in exit gas temperature some other heating surface must have picked up the heat from such a deficiency, if same existed.

Q. It is not uncommon for "distant tubes" to buckle as in this instance. For instance, in a well known horizontal water tube boiler upper tubes considerably distant from the lowest row frequently give trouble due to buckling and burning. It has been found that the cause is not improper baffling of the flue gases but rather is due to improper baffling of the water. Steam bubbles from below rush past the openings of the upper tubes at such a rapid rate that the water cannot get into the upper tubes and the natural result is buckling or burning.

A. It is the writer's opinion that the circulation of the horizontal or straight tube boilers cannot be compared or paralleled with the vertical or bent tube because of the wide difference in design. The bent tube boiler has always depended on the gas baffling to create the circulation of the water.

Q. For this type of vertical boiler 225 per cent rating is not excessive or unusual. No trouble whatever should be experienced with proper water circulation and clean tubes.

A. These boilers are operated between 275 and 400 per cent of rating, not at 225 per cent as assumed by Mr. Schaphorst, who was evidently misled by the mention of 225 per cent at one point in the article. This 225 per cent was mentioned as the rating in which draft measurements were taken. At the elevated ratings the tube trouble was considerably aggravated.

Q. The general baffling arrangement of Fig. 3 is superior to both Fig. 2 and Fig. 4. Whether or not the baffling for Fig. 3 was correctly computed cannot be judged by simply inspecting the sketch. The arrangement of Fig. 3, however, could have been improved by changing the baffling of the third bank and by constantly carrying out the principle of tapering gas passages. It doesn't "look right" in every respect. The baffling of Fig. 2 is "bad"—parallel flow and unscientific in almost every way. The baffling of Fig. 4 is unorthodox. Even the baffling of the middle bank of Fig. 4 has been made unnecessarily complex. It is obvious that there are "dead spaces" in the first bank, in the second bank, and two dead spaces in the third bank.

A. This baffling arrangement, referring to Fig. 4, does not conform to standard practice as to throat opening dimensions, but they were purposely put in narrow, especially the opening into the third or last pass, in order to guard against too free a flow of gases and the consequent heat loss. It was the intention to start out with them narrow and then open them up later if desirable. Due to the construction of the baffle, it could be shortened physically easier than it could be lengthened. Results, however, were satisfactory immediately so that it was not desirable to change the throat openings.

Q. Further explanation as to exactly why the baffling of Fig. 4 should give better results than Fig. 3 will be much appreciated. We don't doubt that Fig. 4 is giving better results than formerly, but we would like to know why? If the change in baffling caused the improvement, why?

A. 1. It stimulated better flow of water in the front bank by providing full length sweep of gases on all rows of tubes in the front bank.
2. The sub-baffle produced more or less of a shading effect upon the zone that was giving trouble, including the super-heater.
3. Tilting the superheater backwards relieved the localized heat condition from the front pass.

The baffling around the superheater headers was so designed in order to box in the headers to protect them from the high temperatures of the first pass, for to expose such headers to such high temperatures greatly shortens their life. The jog was made in the baffle below the headers to encourage a cross-flow effect to increase the application of the maximum heat to the No. 7 row tubes. If it had not been necessary to provide accessibility to the superheater headers, the jog would have been placed directly underneath and close to the headers. With the latter arrangement the throat between the sub-baffle and the first main baffle would have been shorter, which would have been theoretically more correct. However, no bad effects were noticed from it as installed.

CONCLUSIONS:

In changing existing baffling arrangements, such as was done in this case, there are, of course, many things which enter into the situation which prevent one from doing the job just the way he would like to do it.

It is not claimed that this design, described in the article, is perfect and that thorough research would not improve it. The first unit was used as an experimental unit and after some modifications it was decided that the baffle arrangement was far superior in performance to any previous design. In fact, tests showed that it had overcome all of the bad effects of the other designs without adding any new undesirable effects.

It should be mentioned that the new baffle arrangement did so improve the circulation that it was reflected in the operation of the boilers and was noticed by the boiler operators, who reported that it put new life into the boilers. After these conclusions were reached, the three remaining boilers of this type (1500 hp.) were similarly converted.

These boilers have been in continuous operation for approximately 3 yr. since the latter design was adopted and installed, and they have given excellent performance. There has been no recurrence of the troubles previously experienced.

Let us say that here is a case where satisfactory performance was obtained with a design that might be termed questionable. In such a case, design does not have a chance of "convicting performance." On the other hand, so-called theoretically perfect designs have, in many cases, given extremely unsatisfactory performance. This is just another case of moving forward by going backward.

Cincinnati, O. J. E. TOBEY.

CHAIN DRIVE made by Union Chain & Mfg. Co., with nickel-chrome steel links and 3½ per cent nickel steel pins was installed in 1914 and is still at work with many years of service ahead.

Why Does Brine Foam?

WE ARE HAVING trouble with the foaming of brine at times when replenishing the brine supply in a tank for our candy factory. Could any reader of Power Plant Engineering tell us what might be the cause of this difficulty and how it may be remedied?

FOREST HILL.

Steam Temperatures

IN THE MAY 1933 issue of Power Plant Engineering, page 229, was published the derivation a simple rule for the determination of the saturation temperature of steam from pressure. This rule, applicable to the range of from about 70 to 120 lb., is

$$T = 135\ P^{0.2} = 135\ \sqrt[5]{P}$$

Where T equals the saturation temperature of steam in deg. F.

P equals the steam pressure in lb. per sq. in. ga.

This rule, although simple, requires the use of a slide rule for a quick solution and did not meet fully the needs of many readers. Further inquiry brought forth a still simpler rule

$$T = 198 + \sqrt{P}$$

which was published, with its development, on page 225 of the May 1934 issue. This rule, good for a pressure range of from 25 to 125 lb., is apparently widely used and was sent in by a number of subscribers, the first three being Charles J. Wilder of Lawrence, Mass., Arthur W. Blum of Troy, N. Y., and Ernest W. Bliss of Lynn, Mass.

A number of others sent in various formulas, apparently developed to meet specific needs. Some of the most interesting of these are as follows:

M. Colgrade of Moscow, U.S.S.R., sent in the following rule which is good for from 12 to 30 atmospheres (170 to 430 lb. as an atmosphere is figured as 14.22 lb. per sq. in.):

$$t = 100\sqrt[4]{A}$$

Where t equals the saturation temperature in degrees Centigrade

A equals the absolute steam pressure in atmospheres

Converted to English units, this may be written

$$T = 91.8\sqrt[4]{p + 32}$$

Where p equals the steam pressure in lb. per sq. in. absolute

T equals the saturation temperature in deg. F.

G. F. Matthes of Baton Rouge, La., submitted the following rule, good for a range of from about 75 to 125 lb. ga.

$$T = 316.5 + 0.7\ (P - 70)$$

Where T and P are as indicated previously.

J. M. Row of Redlands, Calif., is sponsor for the following rule, good for a range of from 70 to about 450 lb.

$$T = \left[\left(\frac{p}{P}\right) - (0.2 + 0.0008P)\right] P + 212$$

Where p equals the pressure in lb. per sq. in. abs.

P equals pressure in lb. per sq. in. ga.

T equals temperature in deg. F.

Combating Acid Effects In Battery Maintenance

WHAT TO DO TO combat the effects of the acid has always been a dilemma to the battery maintenance crew. I now have reference to those men who are required to stay for considerable lengths of time in the acid-gaseous atmosphere of the battery room for taking specific gravity readings, making repairs to the lead floor or tank linings, cleaning the copper bus work, etc.

I have found that no suitable protective dipping solution or other means has been found for wool or cotton clothing and that the use of old clothing is the only insurance. These clothes should be rinsed in cold water to dilute the minute particles of acid absorbed after every working day and discarded at the first sign of fibre disintegration. As positive insurance against skin irritation and also destruction of good clothing, the men are advised to take a cold shower at the end of each working day.

For protection of the hands, the Utility company provides rubber gloves. These gloves are ones which have failed electrically and offer no further protection against shock. They have a hole punched in the cuff to distinguish them from those good electrically.

Now with regard to protection of the hair. It has been shown that the human hair even after a cold shower retains in fair concentration acid which it had absorbed in the battery room. Battery men have complained that little holes are eaten in the pillow cases at the end of two or three weeks due to the acid being driven off with the perspiration during sleeping. To counteract the acid collecting in the hair, they are now wearing rubber caps, the type used for swimming. Since this practice was initiated no further complaints have been heard regarding disintegration of pillow cases, etc.

North Bergen, N. J. KERMIT B. HOFFMAN.

Wear in Roller Chain Drives

THE POPULARITY of the roller chain, especially on drives where the speed is not excessive, is due in large measure to the fact that such a drive gives but little trouble. Perhaps the main bad feature about such a drive is the fact that we come to regard it as incapable of giving trouble, and pay little or no attention to it while it is in operation. As a matter of fact, the roller chain drive, good as it is, is still capable of giving trouble, and in some cases where the trouble is not correctly understood, it will continue, and will grow steadily worse.

Like any other mechanism with moving parts continually rubbing together, a roller chain is susceptible to wear. As the chain links pass around the sprocket, the bushings turn within the links. Some wear results,

regardless of how well one may keep the chain lubricated, though proper lubrication will, of course, cut this wear to the minimum. Now, let us see what happens to the drive as a whole when this wear occurs, and as it grows gradually greater.

When a new chain is fitted to a new pair of sprockets, the roller links fit into their places in the sprockets perfectly. As wear occurs on the bushings and pins of the chain, the distances between the centers of the rollers increases a very slight amount. The wear that occurs on the sprocket itself is negligible, but such wear as does occur tends to make it smaller as to the distance between roller seats, rather than larger. As the chain continues to wear, the rollers will no longer seat themselves properly in the sprocket, but will pull against the teeth at a point higher up. This condition causes vibration and even faster wear.

Theoretically, there are two different cures for a chain drive in such a condition. One is to discard the chain in favor of a new one, and the other is to use a slightly larger sprocket to accommodate the elongated chain. The first is the method usually employed, because a chain with worn pins and bushings does not operate to the best advantage, even though a sprocket may be provided in which the rollers will seat themselves properly.

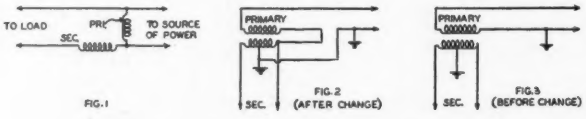
Peoria, Ill. JOHN E. HYLER.

A Low Voltage Complaint and Its Remedy

EVERY ELECTRIC utility company at some time or other has a case of low voltage where the ordinary methods of remedy cannot be financially justified.

Take for instance the case that came to the writer's attention recently. A long three-phase power feeder (unregulated) built under contract to serve a large construction project passed through an outlying summer resort.

This furnished an opportunity to supply this community, and a single phase tap was extended for the purpose. Due to the feeder being unregulated, what



was satisfactory power voltage proved somewhat low during heavy demand periods for this single phase lighting extension.

Obviously the magnitude of this lighting load would not justify the installation of voltage regulators nor even an additional transformer to be used in the usual way (Fig. 1) as a booster.

The problem was taken care of by connecting the transformer serving this lighting load as shown in Fig 2. Fig. 3 shows how it was connected before the change. The connection shown in Fig. 2 results in a 5 per cent boost, of course. In the case cited, where the voltage previously had varied between 110 to 115 it now stays within the limits of 115.5 and 121.

La Crosse, Wis. VERNON W. PALEN.

Method of Marking Switchboard Panels

IN THE turbine plant where I am employed, instructions were posted for the guidance of the engineers to drop the load in cases of emergency such as loss of steam pressure. The machines of the mill are motor driven and no regular switchboard operator is used, the tour electricians handle the board when starting up and shutting down the mill. The panels were marked as follows: On panels with switches of least importance to production, white cards with circuit names printed in black were used and these switches were to be pulled first in case of emergency. On circuits involving paper machines, green cards were used, these switches were to be pulled second if necessary to further reduce load. Red cards designated circuits that could not be opened without involving power house or boiler room. The trouble was the cards soon faded and all looked the same color. I suggested a supply of bolts with red and green glass heads on them, such as are used to fasten license plates on autos. be bought and mounted on the panels above name plate cards on panels requiring red and green markers, and panels requiring black cards be left blank. This was done and we now have permanent markers on the panels that will not fade.

Chillicothe, O. WALLACE BOSTWICK..

Welder Magnetizes Tools

OUR ARC-WELDER has become an indispensable piece of equipment in our repair shop and in addition to it's welding activities we have added a solenoid as an accessory for magnetizing files, tack hammers, etc. A magnetized file or other piece of suitable steel has a great many uses in a repair shop but our facilities for conveniently "charging" the steel has been makeshift as the occasion required until this scheme was worked out.

A 3-in. bakelite tube 10 in. long was wound with 50 turns of No. 6 D.C.C. magnet wire to form the solenoid. The tube and wire were leftovers. We find that this amount of turns will magnetize a file sufficiently to pick up a ¾-in nut without any trouble but a hundred turns would have been much better. A small round file that has been magnetized is useful for removing shavings from bored or tapped holes that don't run all the way through the work.

Of course a magnet only attracts iron and steel so if the brass bolt happens to fall in the crank-case some other kind of "bait" will have to be used to fish it out.

Nashville, Tenn. THOS. E. MILLER.

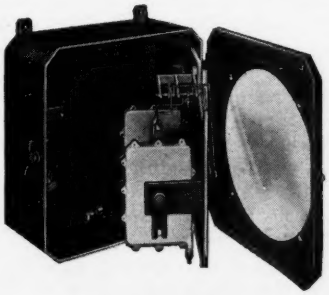
USE OF NICKEL chromium iron gears for large speed reductions is stated by J. W. Neasham, president of Ottumwa Iron Works, Ottumwa, Ia., to give greatly increased life where severe service is involved. In electric hoists, which reverse two or three times a minute under full load during the entire working day, many such gears have been in use for years with practically no replacements.

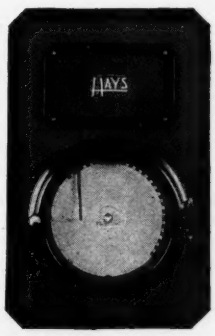
New Equipment

Recording Draft Gages

TWO NEW recording draft gages with 10 in. circular charts are announced by The Hays Corp., Michigan City, Ind. Seth Thomas clock drive is standard on both but Telechron electric movements can be supplied at slight additional cost.

The first, in a 13 by 14 by 7 in. rectangular case, is the Series OT made with one or two pens and for either flush or flange mounting. Three sizes of slack leather diaphragm mechanism are used for various ranges of draft, pressure and differential from 0 to 0.5 in. to 0 to 100 in. Like the Hays





pointer gages, these instruments do not have to be leveled accurately.

The second, is the series OH, a supersensitive recorder for low ranges of differential pressure, 0 to 0.1 in. to 0 to 0.4 in. Actuating mechanisms are 7 in. diam. round slack leather diaphragms. The case, 17½ by 22½ by 9 in. for either flush or flange mounting, is large enough to add one of the smaller rectangular diaphragms as used in the model OT to make a two pen recorder. These cases must be leveled and a spirit level is built in each instrument for that purpose.

New Drop-out Fuse Disconnect

A NEW DROP-OUT fuse disconnecting switch, Type EF-2, has been announced by the General Electric Company. It includes the standard G-E Type EG-1 fuse, of which thousands are in service. When the fuse blows, a latch is released and the switch drops to a 60-deg. position, where it is easily recognized as a blown fuse. When the switch is open manually it drops to 180-deg. disconnect position.

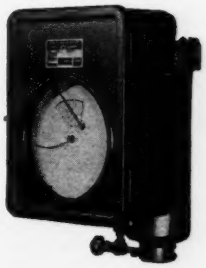
The new switch is available in standard NEMA voltage ratings of from 7500 to 69,000 v., and its fuse with ratings up to 200-amp. size. It can be furnished with gas deflectors to direct any gas, which may occur when the fuse blows,

from other devices within close proximity; when deflectors are used with the 15,000-v. switch the interrupting rating of the fuse is increased from 6,000 to 8,000 amp.

Fuel Flow-Air Flow Meter

RECENTLY DEVELOPED by Bailey Meter Co., Cleveland, Ohio, a new fuel flow-air flow meter guides operators of furnaces and kilns in adjusting conditions so as to obtain maximum combustion efficiency from the fuel burned. By this meter furnace operators are provided with an easily understandable guide which enables them to maintain a definite relation between the amounts of air and fuel supplied to the furnace. The meter contains two recording pens, one records the rate of oil flow or gas flow and is actuated by a simple mechanical mechanism which receives its motive power from the differential pressure produced by an orifice in the fuel line. In a similar manner the second pen records the flow of air supplied for combustion.

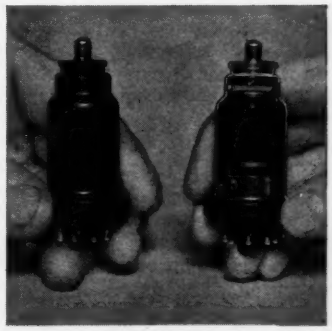
In addition to serving as a combustion guide, the Bailey Ratio Meter is valuable as a Fluid Meter on the fuel line. It records and in-



dicates the rate of flow in any convenient terms and the total flow may be given by a six unit integrator. In this manner, the meter furnishes a daily graphic picture of furnace operation and supplies data for cost-accounting systems.

Metal Electron Tubes Announced by G. E.

A NEW LINE of metal radio tubes, which tests indicate to be of greater continued efficiency of operation than the glass type now in use, was announced recently by



the General Electric Company. These new metal tubes are not only much smaller and more sturdy, but offer many improved electrical characteristics over the conventional tubes of today. They provide their own shielding and this metal shell is a better heat conductor and radiator than glass.

These new tubes are not interchangeable with glass tubes in the present type radio receivers and will make their first appearance in the new fall line of General Electric sets. The new metal technique, of course, is applicable not only to radio tubes but to various types of industrial tubes as well. Large rectifiers, shield-grid Thyratron tubes, and numerous other types have been made with metal construction.

The metal tubes are cylindrical in form, some in reduced diameter at the top. Others, such as a radio frequency amplifier, have a terminal at the top extremity. Each lead-in wire passes through a tiny bead of special glass that is fused securely within an alloy eyelet, which in turn is welded to the metal container, thus assuring a long life vacuum. This alloy, having substantially the same coefficient of expansion as glass, is known as Fernico and is a combination of iron, nickel and cobalt. It was developed expressly for the purpose of a perfect seal on the new tubes.

The inner parts of the tube are first assembled on the steel end plate or header, the shell is placed over the assembly and welded to the header at its circumference. In the main, the new tubes are less than half the size of the familiar glass tubes of corresponding rating. The metal shells are, of course, much stronger than glass bulbs, and not subject to breakage, while the use of short, stiff supports in the new tubes results in less mechanical vibration of the internal elements.

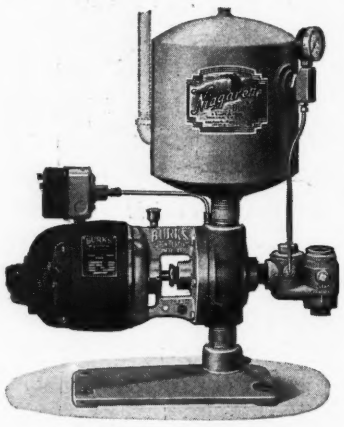
Elimination of the glass "pinch seal," in which all leads and supports are concentrated in the glass tubes, allows the leads to enter the header of the new tube at the proper points for short, direct paths. Also, the new design permits a logical arrangement of connections and supports between base pins and electrode structure.

The familiar metal shield which is necessary with the glass tube in radio-frequency portions of a circuit is no longer required with the new tube. The metal envelope itself serves as a shield.

The new tubes have one more base pin than comparable glass tubes, since the metal envelope has become the shield, and provision must therefore be made to ground this envelope. Designers of the tube have even taken into consideration greater ease of inserting it in the socket. In the present conventional glass tube, two of the base pins are of larger diameter than the others, necessitating alignment of these larger pins with corresponding socket holes. In the base of the new tube, all the pins are of the same diameter, and in the center is a longer insulated keyed pin. By placing this insulated pin in a hole centrally located in the socket, and rotating the tube until the key slips into its groove, the tube is quickly and easily inserted.

Compact Water System

IN THIS SELF-CONTAINED unit are included the motor, turbine pump, water tank and controls, to operate from a.c. or d.c. current and supply 200 or 300 gal. per hr. under total head,—suction, discharge and friction,—up to 50 lb. per sq. in. or 115 ft. It is quickly demountable for inspection and cleaning of pump, or for overhauling the motor and controls. In the Burks super turbine pump, a stainless steel shaft mounted in ball bearings, cast-bronze impeller and raceway, galvanized cast-iron base and casing are used for durability and



economy. Proper volume of air is automatically maintained in the tank, which is welded, then tested and galvanized. The system, which is given the name Niagarette by its makers, Decatur Pump Co., Decatur, Ill., can also be used as a feeder for large storage tanks, in which it will maintain proper air volume.

For handling return condensate, a similar system, given the name Tornado, is manufactured in two types, one mounted on a condensate tank, the other to be installed beside the tank or at a distance from it. The smaller size for up to 4000 sq. ft. radiation is in unit type; the medium size, for 4000 to 10,000 sq. ft., is made in both types; the large size, for 12,000 sq. ft. and over, is made only with tank and pumping unit separate. All units are designed to handle hot water, so long as suction head is not excessive for the temperature, and for total pressures up to 100 lb. per sq. in.

Elgin Isometer

AN ENTIRELY new type of flow meter, which utilizes a varying orifice, is now obtainable from the Elgin Softener Corp. of Elgin, Illinois. As the flow of steam, water, oil, or other liquid or gas varies, the orifice opens and closes. In the Elgin Isometer a constant pressure drop is maintained by changing the orifice opening. The flow is then accurately determined by measuring the amount of orifice opening at any instant.

It is claimed that the varying orifice principle of operation makes it possible to measure low rates of flow accurately down to as low as 2½ per cent of the meter capacity. It is also said that pulsating flows can be more accurately measured and that errors due to friction are eliminated, because the power of the actuator is far in excess of that actually required to move the orifice gate and the metering units are electrically driven.

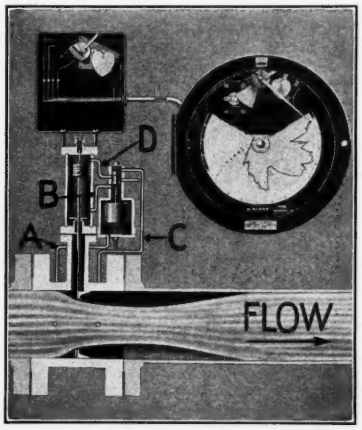
The complete Elgin Isometer consists of two parts: the actuator and the meter unit. The actuator is located in the pipe line and consists of a flanged cylindrical section in the center of which is mounted a set of plates, forming a variable orifice. The actuator utilizes full line pressure, either above or below a small piston located in a vertical cylinder. The upstream pressure is transmitted to the bottom of a small pilot cylinder containing a slide valve. The downstream pressure is transmitted to the top of the pilot piston.

Tube A communicates the upstream pressure to the space beneath the piston and causes the pilot piston to rise, permitting the upstream pressure to be exerted on the main cylinder through tube B beneath the main piston. This raises the main piston and opens the orifice. The orifice will continue to open until the downstream pressure reaches the desired point, at which instant the pilot piston travels downward and shuts off the pressure under the main piston, the orifice opening being held in a fixed position.

If the flow increases, the pilot piston again rises, admitting pressure again below the main piston

and causes the orifice to open further. If the flow in the main pipe line drops off, the downstream pressure, which is transmitted to the top of the pilot piston through tube C, will cause the pilot piston to travel downward, admitting pressure to the top of the main piston through tube D, and opening a drip line venting the main cylinder at the bottom of the main piston. This causes the orifice to close until the required pressure drop again is established.

With the pressure drop established, it is necessary only to measure the opening of the orifice. The vertical movement of the orifice gate is measured by changing the



linear motion of the small stem to rotary motion. The rotary motion operates an electrical time contact device. The time contact device consists of a constantly rotating cam, driven by a clock type motor.

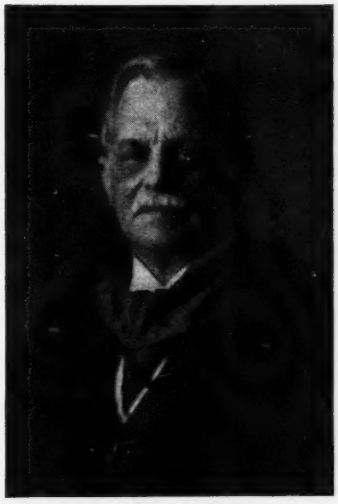
The mechanism which receives the electrical impulses from the actuator is identical to the mechanism mounted on the actuator. Being driven by identical motors supplied from the same plant circuit, the two cams revolve at equal rates of speed. The electrical impulses from the actuator may be transmitted by a two-wire circuit to any remote location.

German Society Honors Elihu Thomson

On the occasion of his 82nd birthday, March 29, Dr. Elihu Thomson, was awarded the medal of honor of the Verein Deutscher Ingenieure, the outstanding award of the German engineering profession. Founded in 1856, the Verein, with a membership of more than 30,000, is the oldest and largest of engineering societies in the world. Its medal of honor has previously been conferred on but five non-Germans, only one of whom was an American—the late Dr. Calvin W. Rice.

Presentation of the medal was made in Boston by Herr Von Tippelskirch, German consul general in that city, on the occasion of a meeting of the board of directors of the General Electric Company, of which Dr. Thomson was one of the founders. On the same day, in Berlin, more than a score of leaders in German science, industry, engineering, and statecraft gathered to do honor to the recipient of the medal.

The citation with the medal read as follows: "On Elihu Thomson, the great pioneer in the realm of engineering, the inventor and research scientist, the promotor of co-operation among engineers, there is conferred, on the anniver-



sary of his 82nd birthday, the V.D.I. medal of honor."

The medal was accepted on behalf of Professor Thomson, whose health confined him to his home in Swampscott, Mass., by E. W. Rice, Jr., who is an old colleague of the recipient, a former president of General Electric, and is now the honorary chairman of its board of directors.

Edward Moreland Heads Electrical Engineering Dept. at M. I. T.

THE APPOINTMENT of Edward L. Moreland as head of the department of electrical engineering of the Massachusetts Institute of Technology was announced on April 9 by Dr. Karl T. Compton, president of the Institute. Mr. Moreland, who is senior partner in the engineering firm of Jackson & Moreland, will succeed Professor Dugald C. Jackson, who retires as head of the electrical engineering department next June.

In announcing the appointment, Dr. Compton said: "Mr. Moreland brings to the department of electrical engineering a broad knowledge of engineering and a thorough understanding of educational requirements in a field in which he has had exceptionally wide experience. Although the future of the electrical engineering department now becomes Mr. Moreland's primary interest, nevertheless he will

continue his active affiliation as senior partner in the firm of Jackson & Moreland, thus maintaining a valuable relationship between technical education and the engineering profession."

The new head of Technology's electrical engineering department is a native of Virginia and a graduate of Johns Hopkins University and of Technology, where he was awarded the degree of master of science in 1908.

He received his bachelor of arts degree from Johns Hopkins University in 1905, coming directly to M. I. T. for his advanced studies. Upon his graduation, he entered the Boston engineering firm of D. C. and Wm. B. Jackson, which in 1919 became the firm of Jackson & Moreland, from which Professor Jackson retired in 1930.

TOOLWELD is the name given by Lincoln Electric Co., Cleveland, Ohio, to a new welding electrode for adding a cutting end to low-alloy steels and for restoring cutting edges on tool steel. Claim is made for 35 per cent saving in annual tool costs and for 15 per cent in tool salvaging.

News From the Field

ON APRIL 1, the Seattle, Wash., District Sales Office of Republic Steel Corp. was removed to the White-Henry-Stuart Bldg. C. D. Winter continues in charge of the office as District Sales Manager, assisted by his present staff to which will be added Archie Rider, recently transferred from the Youngstown offices.

W. S. SHIFFER, General Manager of Sales of the Reading Iron Co., has announced that S. H. Blackwood, formerly Assistant District Sales Representative in the New York territory has been made District Sales Representative in Southern territory with headquarters at 1105 Continental Bldg., Baltimore, Maryland. Mr. Blackwood takes the position held for many years by W. J. White, who recently resigned. W. N. Johnson has been appointed as salesman in the New York territory.

C. B. NOLTE was elected president of Crane Co. on March 26. J. B. Berryman, who had been president since 1931, and who has been connected with the Crane organization since 1892, became Chairman of the Board. As chairman he will be able to transfer his heavy responsibilities to Mr. Nolte's shoulders, and at the same time, will be in position to follow closely the further progress of the company. Since 1909—just after he received his Bachelor of Science degree in Mechanical Engineering at the University of Illinois—Mr. Nolte has been with the Robert W. Hunt Co., consulting, testing, and inspecting engineers. Successively he became division manager, manager, vice-president and general manager, until in 1930, he was appointed president and general manager. This position he held until he was elected to his new office.

R. T. DINWIDDIE has resigned as Manager, Refractories Division of The M. W. Kellogg Co., of New York City to become Vice-President of Refractory & Engineering Corp., 381 Fourth Avnue, New York City. In this new position, Mr. Dinwiddie will be in charge of sales of the company's complete lines of refractory cements and insulations.

THE EAGLE-PICHER LEAD CO., Cincinnati, Ohio, has announced several changes in its organization following the resignation of R. M. Roosevelt, Vice-President of the company, in charge of the New York office, who will devote his full time to duties as President of the American Zinc Institute. Willard E. Maston, Vice-President, has been placed in charge of the New York Sales Division. F. W. Potts, Vice-President, has been appointed General Manager. John R. MacGregor, Vice-President, Eagle-Picher Sales Co., is to have charge of Sales Research and Product Development. T. C. Carter has been appointed Director of Sales.

HORACE T. POTTS CO., Philadelphia, has been appointed distributor of seamless stainless steel pipe in that territory by The Babcock & Wilcox Tube Co., also continuing to distribute B&W seamless boiler tubes.

U. S. SUPPLY CO., Omaha, Neb., has been appointed exclusive sales agent for American District Steam Co. for the State of Nebraska, the western boundary counties of the State of Iowa and the Northeastern section of the State of Wyoming.

RILEY STOKER CORP. announces the appointment of Geerlings and Henschel, 647 West Virginia Street, Milwaukee, Wis., as general agents for the complete line of Riley steam generating and fuel burning equipment for the southern Wisconsin territory.

THE TWENTY-NINTH annual convention of the Smoke Prevention Association will be held in St. Louis, June 4 to 7, inclusive. It is expected this year that the meeting will lay stress upon five aspects of the smoke problem—health, efficiency of fuel-burning equipment, promotional work, scientific progress in the field, and enforcement of smoke-regulating ordinances

ROBERT W. HUNT CO., Chicago, has accepted the resignation of C. B. Nolte, its President who has accepted the Presidency of Crane Co. James C. Ogden, formerly Vice-President in charge of Robert W. Hunt Co.'s eastern and foreign activities at New York, will succeed Mr. Nolte as President. Mr. Ogden has been actively engaged with the organization for the past 35 yr. and in an executive capacity since 1908. He will be assisted in the operation of the organization by F. M. Randlett, as Vice President and General Manager. Mr. Randlett has been Pacific Coast Manager of the company at San Francisco since 1926 and prior to that was Chief Engineer of the Water Department of Portland, Oregon.

AMERICAN ENGINEERING CO. has recently established a district office in the Keyser Building, Calvert and Redwood Sts., Baltimore, Md., with Wm. M. Chatard in charge of the office.

G. W. BRUCKER has been appointed designing engineer of the power rectifier engineering department at the Schenectady Works of the General Electric Co. Mr. Brucker is a native of Albany, N. Y., graduating from Union College in Schenectady in 1921 and entering the General Engineering Laboratory of General Electric in 1923. In 1930, he was made executive assistant of the power rectifier engineering department, holding this position until his recent promotion to designing engineer.

THE COPPER & BRASS RESEARCH ASS'N will have offices at 420 Lexington Ave., New York City, after April 1, the former address being 25 Broadway.

THE EAGLE-PICHER SALES CO. has opened a completely equipped insulation divisional headquarters in the Temple Bar Building, Cincinnati, O., where an engineering staff will assist customers in the solution of their insulation problems with modern materials and modern methods. A complete stock of insulation for the entire range of temperatures will be maintained at these headquarters.

D. H. SKEEN & Co., Chicago, Ill., has recently been appointed sales representative in the Chicago district of the Calorizing Co. of Wilkinsburg Station, Pittsburgh, Pa., to handle calorizing and calite alloy castings which have the qualities of enduring heat and resisting corrosion.

THE DIRECTORS of the Crocker-Wheeler Electric Manufacturing Co. of Ampere, N. J., announce the election of B. D. Christian to the office of Vice-President of the company. Mr. Christian has been identified with Crocker-Wheeler for 21 yr., the past nine of which have been spent as General Sales Manager.

CONTRACT has been awarded to the Westinghouse Electric & Mfg. Co. by the U. S. Department of Interior for four 287.5-kv. oil circuit breakers and accessory equipment for installation at the Boulder Dam generating station. The breakers will serve as protection for the station against faults that may occur on the Boulder-Dam-Los Angeles transmission line. The amount of the contract is approximately $500,000.

CAPTAIN WALTER MARTIN MCFARLAND, U. S. N., retired, for 20 yr. manager of the Marine Department of The Babcock & Wilcox Co., New York, from active service in which he retired in 1931, died at his home, Washington, D. C., March 4, after a brief illness. Born on August 5, 1859, in Washington, he attended the district public school and Columbian University Preparatory School, now George Washington University, later entering the United States Naval Academy, from which he was graduated second in the class of 1879. After graduation, in addition to periods of sea service in various parts of the world, he was for a time inspector of machinery for naval vessels under construction, and was twice attached to the Bureau of Steam Engineering as assistant to Admiral George W. Melville, Engineer-in-Chief.

JACOB T. BARRON has been named vice president in charge of electric operation, Public Service Electric and Gas Company, succeeding Edgar Allegaert who died February 26. Mr. Barron has been general manager of the Electric Department. Mr. Barron also was elected a director of the underlying operating companies of Public Service in place of Mr. Allegaert. Marion Penn, general superintendent of generation, succeeds Mr. Barron as general manager, and Walker L. Cisler, planning and installation engineer, becomes general superintendent of generation, in place of Mr. Penn.

GRANT W. SPEAR, formerly of Aurora, Illinois, and for the past twenty years Vice-President of the Dearborn Chemical Co. at New York City, died at Palm Beach, Florida, March 22, at the age of sixty-nine. He graduated from the University of Illinois—class of '87. His wife Mary Carr Spear and daughter, Miss Emily Spear, survive. For the past five years Mr. Spear had been in ill health and had retired from active duties with the Dearborn Chemical Co.

A SUMMARY of an investigation of engineering education and related activities made over a period of years by the Society for the Promotion of Engineering Education has been published by the Society and may be obtained from the secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. The summary is a 37 p. booklet while the complete report published in two volumes comprising 1700 pp.

THE FIRST complete factory in this country for the exclusive manufacture of Diesel locomotives will be built by the Austin Co. of Cleveland, Ohio, at McCook, Ill., for the Electro-Motive Corp., a subsidiary of the General Motors Corp. McCook is in the Chicago industrial district and the locomotives built there will be powered with engines built in Cleveland by the Winton Engine Co.

For the Engineer's Library

"ACCURATE Flow Measurement with Elgin Isometer" is the title of an informative 12-page bulletin issued by Elgin Softener Corp., Elgin, Ill. This new product is used to indicate, record and integrate the flow of liquids and gases.

"REMOVE THE MENACE OF DUST" is the title of a new booklet recently issued by the United States Hoffman Machinery Corp., 105 Fourth Ave., New York City. This literature deals with the Hoffman heavy duty vacuum cleaning equipment and many illustrations are used in describing the cleaning system in detail, as well as its use in industrial plants.

ILLUSTRATING and briefly describing the advantages of using Brown instruments for reducing costs in boiler room and plant processes, The Brown Instrument Co., Philadelphia, Pa., has issued an attractive folder showing how Brown instruments tell when, where and how much steam is produced and used in the plant.

THE MARLEY Co., Kansas City, Mo., has issued its bulletin No. 54 illustrating the Marley water cooling equipment which is complete for towers and spray ponds.

FORGED FLANGES is the title of a new bulletin issued by Kropp Forge Co., 5301 Roosevelt Road, Chicago, Ill. The bulletin deals particularly with double hub and high hub boiler flanges.

REVISED RULES and regulations governing the details of fuel burning equipment of Hudson County, N. J., have recently been issued by the Department of Smoke Regulation, Court House, Jersey City, N. J., and copies may be obtained by those interested by sending three cents to cover postage.

FOR MEASURING the temperature of flat or curved surfaces, such as pipes, The Pyrometer Instrument Co., 103 LaFayette St., New York City, has developed the new Pyro Surface Pyrometer described in Bulletin No. 60. The pyrometer is made in two models, one with an offset handle for flat surfaces and the other for rolls and curved surfaces. They weigh about 2¾ lb. each and the temperature ranges extend as high as 1400 deg. F. The unit consists of the thermocouple element and a direct reading galvanometer.

IRON FIREMAN MFG. Co., Portland, Ore., has recently issued its catalog No. P38 entitled Iron Fireman for Power, which not only describes the features of construction in the latest types of Iron Fireman stokers, but gives pertinent information relative to the history of this stoker in industrial use.

GENERAL engineering data on electrolytic and oil-filled industrial condensers as well as their application to motor-starting, power-factor correction and other industrial uses, is presented in a 28-page manual and catalog just issued by the Aerovox Corp., 70 Washington St., Brooklyn, N. Y. The manual is available to manufacturers and engineers of electrical equipment calling for industrial type condensers, requesting a copy on their business letterhead.

GREAT STRIDES in belt manufacture are pictured in a new folder issued by The B. F. Goodrich Co., Akron, O., which lists 14 different improvements in belt construction which have been effected during the past 5 yr. Six of these are improvements in manufacturing process, four in fabric used, four in rubber compounds.

IN A FOLDER on The World's Largest Plate Mill, Lukens Steel Co., Coatesville, Pa., illustrates and describes some of its products, showing the wide variety of articles produced.

THE LOUIS ALLIS Co. of Milwaukee, Wisc., publish regularly every other month a 24-page company magazine for those interested in the purchase or maintenance of electric motors. This magazine is attractively printed and contains engineering data and technical articles on electric motors and other equipment.

Copy of this 24-page magazine will be sent with the company's compliments.

PARKER APPLIANCE COMPANY, Cleveland, Ohio, have just issued Bulletin No. 38, a 60-page booklet covering a typical variety of valves manufactured by that company. This bulletin contains all necessary technical information as well as prices.

TRIP FREE AIR CIRCUIT Breakers, for buildings, industrials and power stations, is the title of a new 4-page leaflet, GEA 1662A just issued by General Electric Co. Another leaflet, GEA 1885, is devoted to the subject of low voltage secondary cables.

LINK-BELT Co., Indianapolis, Ind., has recently released a highly pictorial 32-page book No. 1425, which presents Silverstreak, a modern high speed chain drive, in terms of what it has done and can do for its users. Many types of applications, on both long and short centers, are shown.

UNBALANCE IN ALTERNATING CURRENT ROTATING MACHINES, by E. M. Sabbagh, is the subject of Research Series Bulletin No. 45 recently issued by the engineering experiment station of Purdue University. This bulletin is available at a cost of 50 cents.

A NEW TYPE E STOKER catalog of 16 pages, describing this center-retort, underfeed stoker, has just been issued by Combustion Engineering Co., 200 Madison Avenue, New York, N. Y. The new catalog contains a complete description of every phase of the stoker's construction, operation and control. An introductory chapter on the economics of buying a stoker and numerous diagrams showing typical ash pit and air duct arrangements, as well as applications to various types of boilers, have been included.

CHARLES A. PARSONS' SCIENTIFIC PAPERS AND ADDRESSES. Edited by G. L. Parsons. Published by The University Press, Cambridge, England and The MacMillan Co., 60 Fifth Ave., New York, N. Y. Size 7 by 10½ in., cloth bound, 249 pp. Price $4.50.

Perhaps no single individual has had greater influence on the development of the power industry than Sir Charles A. Parsons, inventor of the reaction turbine. It is fortunate indeed that this well edited volume of his collected papers has beeen produced to give a picture of a great engineer as reflected in his own works. The human side of the picture has been added by a short but delightful foreword by Lord Rayleigh who from personal remembrances presents Parsons the man beloved by the countryside. The book itself is divided into three parts, the first dealing with his work with the development of the steam turbine; the second his research into the artificial manufacture of diamonds and the third his work with optical glass and the Auxelophone, an air valve operated loud speaker.

AIR CONDITIONING AND ENGINEERING. Published by the American Blower Corp., Detroit, Mich. Size 9 by 11½ in., cloth bound, 350 pp. plus 332 pp. catalog and equipment section. Price $5.

Covering the entire field of air conditioning and engineering, this book, complete with charts, photographs, drawings and tables, incorporates the experience of the company's own engineers and data gathered from other reliable sources, to bring about a complete and authentic library on the subject in one volume. Section 1, the technical section, is divided into 23 chapters and the subjects covered include air, heat, steam, air flow, sound, heating, ventilating, humidifying, dehumidifying, cooling, control, vapor absorption, drying, etc. All subjects are indexed, charted, illustrated and cross indexed, to permit easy research reference.

Illustrations are well selected and clearly reproduced, the text well written and the charts and tables large and complete enough to be of practical use for calculation purposes. Many of these are folded inserts opening up to an 11 by 15 in. sheet so as to reproduce the charts in usable size.

THE IDEAL ELECTRIC & MFG. Co., Mansfield, Ohio, announces a 16-page booklet describing in detail the Noel "Speed-Arc" Welder. The advantages claimed for this welder are high power factor, high efficiency, and a high speed arc. Power factor is 100 per cent at full load, and its arc has an unusually high recovery speed.

DEARBORN CHEMICAL Co., Chicago, Ill., has recently issued a number of leaflets dealing with water treatment and rust prevention under the titles Tannin Brick Water Treatment, Round Stick Water Treatment, Compressed Brick Water Treatment, Sealing Compound, Chemical Pump, Concentration Hydrometer and No-Ox-Id Rust Preventive.

BUFFALO COOLING and Air Conditioning Units is the title of Bulletin No. 2967 recently issued by the Buffalo Forge Co., Buffalo, N. Y. This bulletin deals with the suspended unit coolers, floor type unit coolers, flat suspended unit coolers and units using brine spray, also central air conditioning cabinets designed for use in stores, restaurants and offices.

PUBLISHER'S STATEMENT OF CIRCULATION

This is to certify that the average circulation per issue of POWER PLANT ENGINEERING for the six months' period, July 1st to and including December 31st, 1934, was as follows:

Copies sold 18,383
Copies distributed free..... 555
Total 18,938

(Signed)...TECHNICAL PUBLISHING COMPANY
(Publisher)
by K. L. Rice.

Subscribed to and sworn before me on this 19th day of April, 1935.
I. Audrea Kiland,
(Seal) Notary Public.

Power Plant Construction News

Calif., Mountain View—Allan Cutler, Inc., 2065 Cowper Street, Palo Alto, Calif., plans installation of power equipment in new multi-unit food products canning plant on 12-acre tract of land at Mountain View. A steam power house will be built for processing and other factory service. Entire project is reported to cost about $200,000.

Calif., Placerville — Placerville Fruit Growers' Association has plans for new precooling and ice plant, and soon begins project. Cost over $200,000, with equipment. Masten, Hurd & Rothe, 233 Post Street, are architects; Paul Scherrer, last noted address, is mechanical engineer.

Calif., San Diego—Consolidated Aircraft Corporation, 2050 Elmwood Avenue, Buffalo, N. Y., plans installation of electric power equipment in new one-story branch plant, 300 x 900 ft., on Atlantic Street, San Diego, for flying boat-manufacture. Cost over $400,000. Major Reuben H. Fleet is president.

Calif., Santa Monica—Douglas Aircraft Co., 3000 Ocean Park Boulevard, plans installation of electric power equipment in proposed new addition to aircraft manufacturing plant. Entire project will cost close to $50,000.

Colo., Fort Collins—City Council has plans maturing for new municipal electric light and power plant, and electrical distribution system. Cost estimated at $740,000. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ga., Savannah—Union Bag & Paper Corporation, Woolworth Building, New York, N. Y., plans installation of electric power equipment in new pulp and paper mill, and paper-converting plant at Savannah, where tract of land is being secured. A power house will be built for mill service. Entire project will cost over $3,000,000. Alexander Calder is president.

Iowa, Boone—At recent special election, proposed bond issue of $850,000 for new municipal electric light and power plant was defeated by vote of citizens. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Iowa, Fairfield—City Council has been authorized at recent special election to arrange bond issue of $100,000, fund to be used for new power station for waterworks plant, using Diesel engine units. Also for power lines and service facilities. Plans will be prepared at once.

Mass., Andover—Board of Selectmen is considering construction of new municipal electric light and power plant. Proposed to secure estimates of cost at early date.

Mich., Detroit—Dodge Brothers Corporation, Lynch Road, Hamtramck district, will install electric power equipment in new one-story addition to automobile works, 96 x 576 ft., for commercial car production. Entire project will cost about $250,000. Company is a subsidiary of Chrysler Corporation, 341 Massachusetts Avenue, Detroit.

Mich., Lansing—Olds Motor Works, Inc., plans installation of electric power equipment in connection with an expansion and improvement program for large increased production. Fisher Body Co., an affiliated interest, will occupy neighboring works of Durant Motors Corporation, recently acquired, vacating space for Olds development noted. Fisher company will also provide electric power facilities for larger output. Both companies are subsidiaries of General Motors Corporation, Detroit. Cost about $400,000.

Minn., Chisholm—Board of Education, Joseph Grams, president, is considering new electric power station to furnish service for all local schools. Cost about $25,000.

Minn., St. Paul—St. Paul Hydraulic Hoist Co., South Walnut Street, plans installation of electric power equipment in connection with proposed rebuilding of portion of hoisting machinery manufacturing plant, recently destroyed by fire. Loss reported close to $80,000.

Mo., Crystal City—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of power equipment in connection with expansion and improvement program at safety sheet glass works at Crystal City. Entire project is reported to cost over $250,000. Company engineering department is in charge.

Mo., Pattonsburg—Common Council has completed plans and will take bids for new municipal electric light and power plant, using Diesel engine-generator units. Cost about $65,000. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

N. J., Long Branch—Board of Directors, Monmouth Memorial Hospital, is completing plans for new power plant at institution. A mechanical laundry unit will also be built. Fund of $68,000 has been arranged for project. Epple & Kahrs, 17 Washington Street, Newark, N. J., are architects.

Ohio, Elyria — Western Automatic Machine Screw Co. plans installation of electric power equipment in new one-story plant addition, 190 x 209 ft. Cost over $100,000. Headquarters are in Engineers Building, Cleveland, Ohio. B. C. Franklin is general manager.

Ohio, Youngstown—Carnegie Steel Co., Carnegie Building, Pittsburgh, Pa., has plans for new steam power house at Ohio Works, Youngstown, adjoining present power station. Cost over $500,000, with equipment. Work will be carried out in connection with general expansion program at mills.

Okla., Cushing—City Council plans early call for bids for new municipal electric light and power plant, to include installation of Diesel engine generator units and accessories, transformers, switchboard and auxiliary equipment, and electrical distribution system. Cost $340,000. W. R. Holway, Tulsa, Okla., is consulting engineer.

Ore., Salem—Columbia Distilleries, Inc., 404 Pittock Block, Portland, Ore., J. E. Wood, manager, plans one-story steam power house at proposed new distilling plant at Salem, where tract of land is being secured. Federal permit has been obtained to operate distillery. Cost close to $75,000.

Pa., Bradford — Northeastern Container Corporation, recently organized, plans installation of electric power equipment in new local corrugated container manufacturing plant. Company has acquired former factory of Hanley Machine Co., and will remodel and equip for new plant. Entire project will cost about $70,000.

R. I., Exeter—State Department of Public Welfare, State House, Providence, R. I., plans extensions and betterments in power station at State School, Exeter, with installation of new boilers, automatic stokers and accessories. Cost about $25,000.

Tenn., Johnson City—City Council is considering installation of new electrical distributing system, with power substation and transmission line connecting with TVA power system, for municipal-owned service. Proposed to arrange fund of about $700,000 through Federal aid.

Texas, Beaumont—Magnolia Petroleum Co., Magnolia Building, Dallas, Texas, plans installation of power equipment in connection with proposed rebuilding of portion of oil refinery at Beaumont, recently destroyed by fire, with loss estimated about $400,000.

Texas, Corpus Christi—Morris Stern, Majestic Building, San Antonio, Texas, is at head of project to construct and operate a new cold storage and refrigerating plant on Chaparral Street, Corpus Christi, where site has been secured. Cost about $70,000, with equipment. Proposed to begin work in near future.

Texas, Houston—International Harvester Co., Commerce Avenue and Hamilton Street, plans installation of electric power equipment in new local one-story agricultural equipment assembling works on Navigation Boulevard, totaling about 100,000 sq. ft. floor space. Entire project will cost close to $125,000. Main offices of company are at 606 South Michigan Boulevard, Chicago, Ill.

Va., Richlands — Appalachian Electric Power Co., Roanoke, Va., plans new transmission line from Grundy to Richlands and vicinity, with power substation at latter place. Extensions will be made in distribution lines for service in that district. Entire project will cost over $100,000. Company engineering department is in charge.

Va., Richmond—Philip Morris & Co., Inc., Twentieth and Main Streets, plans installation of electric power equipment in new three-story addition to tobacco factory. Cost close to $100,000. Proposed to begin superstructure at early date.

Wis., Chippewa Falls — Chippewa Falls Woolen Co. plans installation of electric power equipment in new two-story mill addition. Company will also build new one-story boiler plant, 20 x 34 ft. Entire project will cost over $50,000. Carl Volkman, McGrath Building, Eau Claire, Wis., is architect.

Wyo., Casper—Wyoming Distilling Co., care of J. E. Scott, Casper, head, plans installation of electric power equipment in new local distilling plant. A steam power house is proposed for distillery service. Entire project will cost close to $100,000.